

Comparison of Insect floral Visitors of Invasive Alien *Sphagneticola trilobata* and *Dillenia suffruticosa* and Native *Melastoma malabathricum* in the Wet Zone of Sri Lanka

Thotagamuwa A¹, Kariyawasam M¹, Ranwala S, ² Yapa W. B^{1*}

¹Department of Zoology & Environment Sciences

²Department of Plant Science

University of Colombo, Colombo 3

**Corresponding author*

ABSTRACT

Invasive plant species are known to have profound negative effects on natural communities and often influence the demography of plant populations and genetic structure of the invaded communities. . This study was conducted to compare the insect visitors of two invasive alien plant species (IAPS): *Dillenia suffruticosa*, *Sphagneticola trilobata* with a co-occurring native plant, *Melastoma malabathricum*, along the borders of Yagirala Forest Reserve (YFR) and Seethawaka Wet Zone Botanical Gardens (SWBG). Insects belonging to the orders of Hymenoptera, Coleoptera, Diptera visited the studied plant species. Lepidopterans were seen only in *S. trilobata*. Bees were the dominant group of insects followed by ants. Fourteen species of bees visited the plant species with three bee species being common to all three plant species. Seventy percent of bees were shared between *D. suffruticosa* and *M. malabathricum*. Visitation rates were calculated for bees only as they were the dominant and common group. The mean visitation rates were significantly reduced for *M. malabathricum* (0.051 ± 0.007) in the presence of *D. suffruticosa* ($t(28) = 4.3, p < .05$) at Yagirala study site. There was no significant difference in visitation rates for the other study sites. Lowest visitation rates (YFR= 0.006 ± 0.001 , SWBG= 0.074 ± 0.01) were observed for *S. trilobata* for all sites. The study provided evidence for the reduced insect visitation for native species in the presence of IAPS, probably due to the presence of better pollination syndromes.

Keywords: Insect visitors, visitation rates of bees, invasive alien plants, pollination

INTRODUCTION

Reproduction in angiosperms is mediated by biotic and abiotic agents, and animals play a key role in pollination. Biotic pollination facilitated by animals is more common and effective than abiotic means, and around 90% of all flowering plants are reported to be pollinated by animals (Renner, 1998). Pollination is a common mutualistic interaction that takes place between biological organisms in which plants achieve reproductive success and the animals gain food as a reward. At least 130,000 species of animals are reported to be regular flower visitors and potential pollinators (Kearns *et al.* 1998). There are at least 25,000 species of bees included into

this total, which are said to be obligate flower visitors and/or important pollinators (Buchmann & Nabhan, 2012). Animal visitations to flowers are encouraged by the floral traits which play a critical role in attracting the best pollinators. This phenomenon is termed by Fenster *et al.* (2004) as “pollinator syndromes” which could be seen in many native and invasive alien species. Native plants have evolved over thousands of years in their home range, have been physiologically and morphologically well adapted to the environmental conditions, and consequently do not inflict threat to neighbouring plants.

Invasive alien plant species (IAPS) are defined as plants that have escaped their native range due to unintentional or intentional human involvement or without help of people into various new habitats and threaten biodiversity and ecosystem functioning of their new environment (Pysek *et al.* 2004). Invasive alien plants have gained significant attention throughout the world due to their adverse effects on environment, economy and human livelihood and wellbeing. Among the many negative impacts caused by invasive alien plant species to native flora, is the suppression of reproductive success of native plant species in the same environment. Many studies on plant- pollinator interactions between invasive and native species have documented negative effects between IAPS and native plant pollinators. It is reported that negative impacts exist mainly in two ways, through effects on pollinator behaviour and pollinator populations (Graves and Shapiro, 2003). Negative effects on pollinator populations are reported to be brought by reducing the native species richness thus affecting the diversity and abundance of highly adapted pollinators to native plants (Cox and Elmqvist, 2000). Direct negative effect on pollinator populations was reported by Graves and Shapiro (2003) by demonstrating that the three pollinator butterfly species that lay eggs on native species were forced to lay eggs on nearby invasive taxa which contained chemical compounds toxic to larva. However, presence of invasive species can also affect pollinator populations positively. The positive effect of IAPS could be brought by increasing the overall pollinator population size via providing more resources to the environment as this in turn can contribute to sustain or increase the rate and number of pollinator visitors to the native plants (Bjerknes *et al.*, 2007). Having different flowering seasons between invasive and native species also facilitates to maintain large populations of pollinators throughout the year. It can also promote pollinator visitations to native species at different flowering season, as the large populations that were attracted to early flowering invasive species will be available for the later flowering native species (Bjerknes *et al.*, 2007).

The effects of invasive alien plant species on pollination of neighbouring native species have not been directly studied although pollination of bees and floral relationships have been studied to a certain extent in Sri Lanka (Karunaratne *et al.*, 2005; Wanigasekara & Karunaratne, 2012). The objective of this study was to identify and compare the insect visitors and their visitation rates to flowers of co-occurring native and invasive alien species in two selected locations in the Low Land Wet Zone of Sri Lanka.

MATERIALS AND METHODS

a. Selected plant species and their floral morphology

The two IAPS namely *Sphagneticola trilobata* (“Wedella”) and *Dilienia suffruticosa* (“Para”) and a native species *Melastoma malabathricum* (“Bovitiya”) that is often associated with them were selected for the study. *Sphagneticola trilobata* and *Dilienia suffruticosa* are two widely distributed IAPS in the Wet Zone of Sri Lanka. They are included in the list of invasive alien species in Sri Lanka (Ministry of Environment, 2015), under the high priority category. *S. trilobata* is a nectar - less creeper belonging to Family Asteraceae with bright yellow heads containing ray florets of about 8-13 (Figure 1A). *Dilienia suffruticosa* is a light demanding woody shrub in the Family Dilleniaceae. This species has large, showy, yellow flower petals with whitish reproductive parts in the centre (Figure 1B). *M. malabathricum* is a native shrub belonging to the Family Melastomataceae, widely distributed in the Low land Wet Zone. Its inflorescences contain large, showy, purplish-pink, nectar less, flowers (Figure 1C) that contains two whorls of stamens (Luo *et al.*, 2008). The stamens of the inner whorl are shorter and yellow and the stamens of the outer whorl are longer and violet.

b. Study sites

The study was conducted in two locations in the Low land Wet Zone of Sri Lanka, in the periphery of Seethawaka Wet Zone Botanical Garden (Colombo District) and Yagirala forest reserve (Kalutara District) where all three studied plant species co-occurred. Figure 1:D,E,F). At each location several random sub sites were observed to record the insect visitors. Insect visitation rates were obtained for two sub sites in each location.

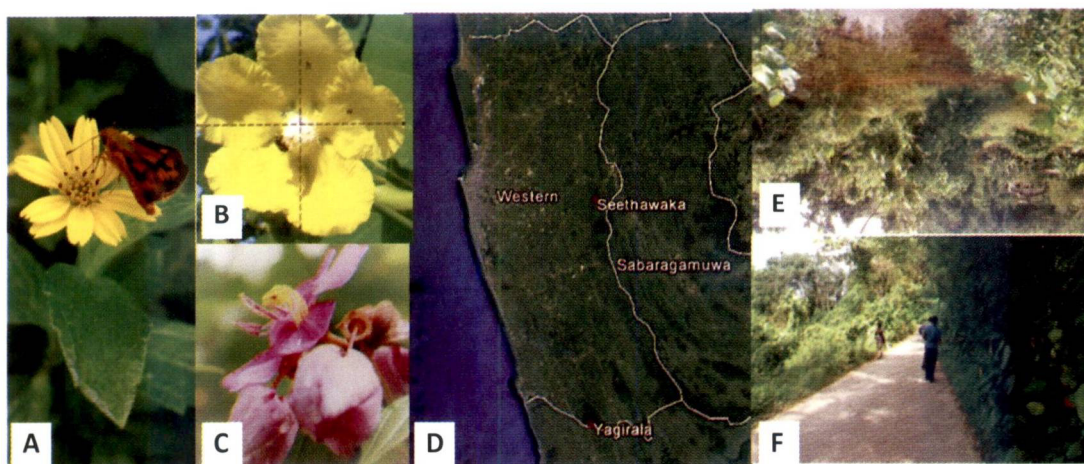


Figure 1. (A) *Sphagneticola trilobata* (B), *Dilienia suffruticosa*, (C) *Melastoma malabathricum*, in bloom at the study locations (D) Map of sampling locations and sites (E) Seethawaka (F) Yagirala

c. Monitoring of insects that visit flowers

Insect visitors to sampling sites were monitored by time constant sampling for durations of fifteen minutes between 8:00a.m-4:00p.m, during which the number of visual encounters of insects were recorded on selected number of flowers depending on their availability and accessibility. During each sampling session, only the insects which alighted on reproductive parts of flowers were recorded (Totland *et al.*, 2006). The visitation percentage for insects belonging to major taxonomic groups was calculated using the total visual sightings for each plant species (Number of flowers=250±20) during a single sampling session (8.00a.m -12.00 p.m.). The values are provided in Table 1.

d. Identification of insect visitors

Insects were collected using standard insect nets and insect aspirators into ethyl acetate treated killing jars and stored in plastic vials. Specimens were identified to the lowest possible taxa using keys for Sri Lankan insect groups (Karunathne, 2009, Dias, 2014, Jayasinghe *et al.*, 2013). The identity of the collected bee specimens were cross checked with the collections at the Peradeniya University and were confirmed by Dr.Inoka Karunarathne, an expert on Sri Lankan bees. Photographs of several, selected bee species are included in the SANex. The observed bees are shown in Figure 2 and species belonging to other groups are provided in the Annex.

e. Calculations of insect visitation rates

The duration of a sampling session for insect observations was thirty-minute. During each session a fixed number of flowers/florets of each species were observed depending on availability and accessibility. Only the number of bee visits was recorded as bees are reported to be the main pollinators. Insect visitation rates were calculated using the following equation (Totland, 2003). A sample set of values used for the calculation are provided in Table 2 with a summary and included in the Annex.

$$\text{Insect visitation rate (VR)} = \frac{\text{number of insect visits}}{\text{number of flowers} \times \text{number of minutes}}$$

f. Data Analysis

Data was analyzed by Two Sample T test using Minitab statistical software package. Visitation rates of only bees were calculated. Two sample T test was carried out to test the following hypothesis.

H_0 : No difference in the Mean bee visitation rates between native and invasive plants (i.e between *M.malabathricum* and *S.trilobata* and *M.malabathricum* and *D.suffruticosa*)

H_a : There is a difference in the Mean bee visitation rates between native and invasive plants (i.e between *M.malabathricum* and *S.trilobata* and *M.malabathricum* and *D.suffruticosa*)

RESULTS

Flower Visitors

As shown in the Table 1 flowers of all three plant species were visited by bees, ants, beetles and flies. Insects belonging to orders Hemiptera and Orthoptera were also seen resting on flowers and are represented under the ‘others’ category. Butterflies were only observed on flowers of *S.trilobata* (Table 1). Bees were the most frequent visitors to all three plant species (>50% of visitations) followed by ants. Among the observed insect groups bees, beetles, butterflies and flies were reported to be pollinators (Kevan & Baker, 1983). Ants were excluded from being considered as pollinators because of their limited dispersal capability and reported toxic effect of their secretions to pollen (Kevan& Baker, 1983).

Table 1-Percentage of visitation by insects based on the total observations

Plant species	Location	Percentage visitation ^a					
		Bees	Ants	Beetles	Flies	Butterflies	Others ⁺
<i>S.trilobata</i> [*]	Seethawaka	91(231/253)	4(10/253)	0.4(1/253)	0.4(1/253)	2.4(6/253)	1.6(4/253)
	Yagirala	71(121/170)	NR	1.2(2/170)	NR	17.1(29/170)	10(17/170)
<i>D.suffruticosa</i> [*]	Seethawaka	84(252/300)	14(41/300)	1(4/300)	0.7(2/300)	NR	0.3(1/300)
	Yagirala	84.8(373/400)	6.4(28/440)	8.2(36/440)	0.9(2/440)	0.2(1/440)	NR
<i>M.malabathricum</i>	Seethawaka	62.4(360/577)	24.3(140/577)	4.5(2/577)	7.98(46/577)	NR	0.5(3/577)
	Yagirala	51.8(205/394)	28.1(111/394)	11.4(45/394)	8.1(32/394)	NR	0.5(2/394)

^aPercentage Visitation rate was calculated using the total number of visual encounters for each group observed during a single sample session conducted from 8.00a.m -12.00 p.m.(Number of flowers observed for all the species =250±20) ^{*}Invasive alien plant species, ⁺others: bugs and grass hoppers NR-Not recorded

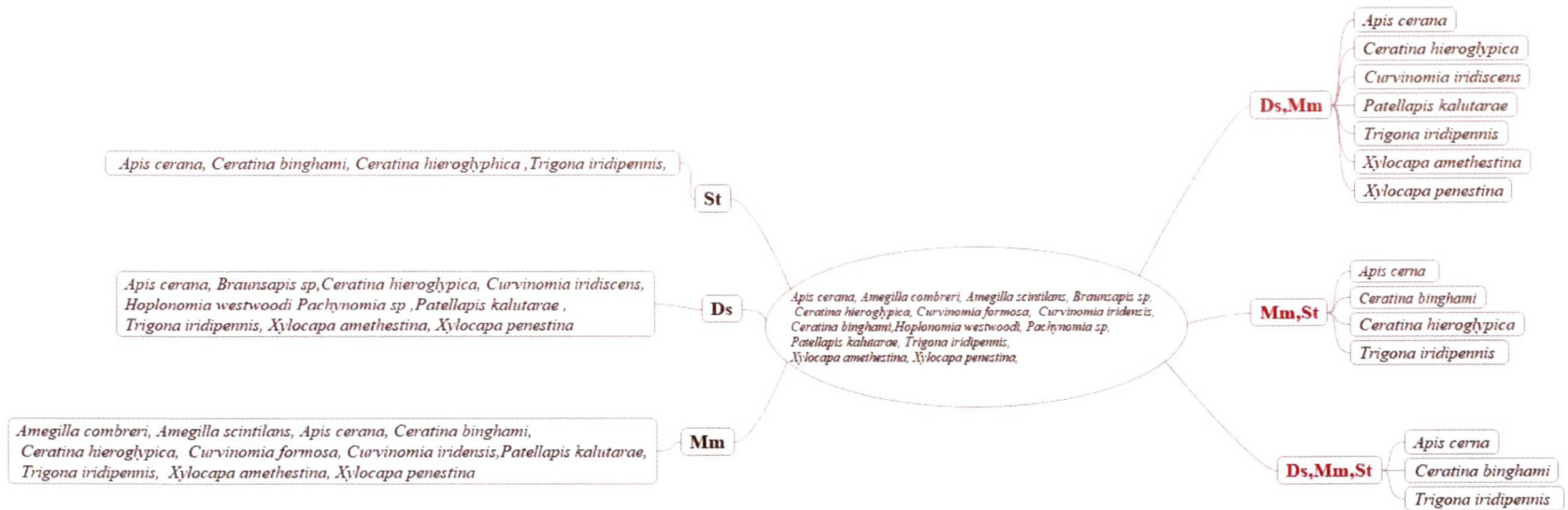


Figure 2. Schematic representation of relationships between bees and studied plant species. Red Bold lettering represents bees shared between studied plant species: *D.suffrusicosa* (Ds), *M.malabathricum* (Mm), *S.trilobata* (St)

As shown in Figure 2, a total of 14 species of bees were recorded from flowers of the study plant species. Four species of bees were recorded from the invasive *S.trilobata*. From the invasive *D.suffrusicosa* and native *M.malabathricum* 10 species of bees were identified. Three species of bees namely *Trigona.irridipennis*, *Ceratina hieroglyphica* and *Apis cerna* were observed commonly foraging in all three floral species. Among the invasive *D.suffrusicosa* and native *M.malabathricum*, 7 species of bees were shared. This accounts for more than 70 % (7/10 species) of bee species visiting each plant species and strongly indicates a possibility of heavy competition among these species for pollen.

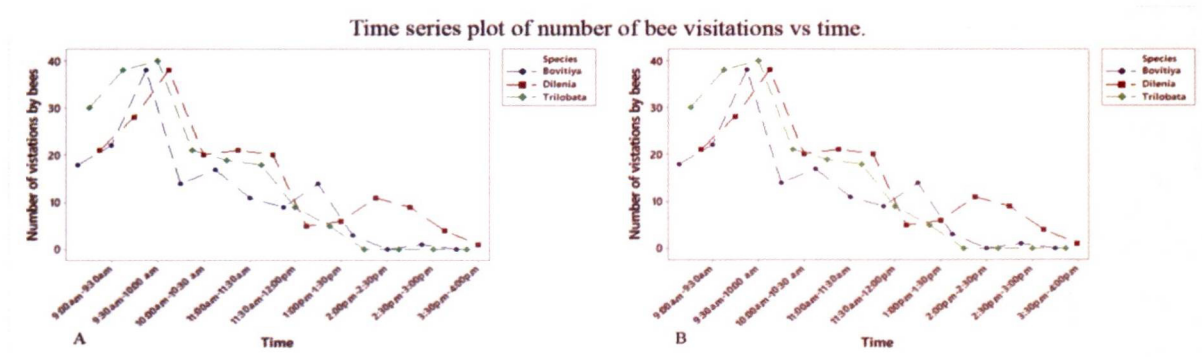


Figure 3.Time series plots for the number of visitations by bees made between 8:30a.m.-4:00p.m. for the invasive *Dillenia suffruticosa* (Dilenia), *Spagneticola trilobata* (Trilobata) and native *Melastoma malabathricum* (Bovitiya) at (A)Seethawaka, (B)Yagirala site

Analysis of visitation rates indicated that activities of bees were high in the morning compared to evenings. (Figure 3). Two sample T test between *D.suffrusicosa* (Ds) and *M.malabathricum* (Mm) (T=4.3); Mm and *S.trilobata* (St) (T=6.5) showed a significant ($p<0.05$) difference in visitation rates of bees for the native and invasive alien plant species at the Yagirala site. In the presence of Ds mean bee visitation rates were higher (0.099 ± 0.008 , $n=28$) than Mm (0.051 ± 0.007 , $n=28$) and St (0.006 ± 0.001 , $n=28$). However, at Seethawaka site there was no significant difference in bee visitation rates between the invasive and alien plant species Ds, St and native species Mm ($P>0.05$). The mean visitation rates for Ds (0.08 ± 0.00 , $n=28$), Mm(0.08 ± 0.007 , $n=28$) and for St(0.07 ± 0.01 , $n=28$) are shown in Figure 4.

Based on the results a clear difference in the visitation rates of bees was observed between the invasive and native floral species. Hence the postulated null hypothesis can be rejected. A mixed effect was observed for native *M. malabathricum* in the presence of *D.suffruticosa* at the two study sites. However, the visitation rates of bees were not affected for the native floral species in the presence of invasive *S.trilobata*.

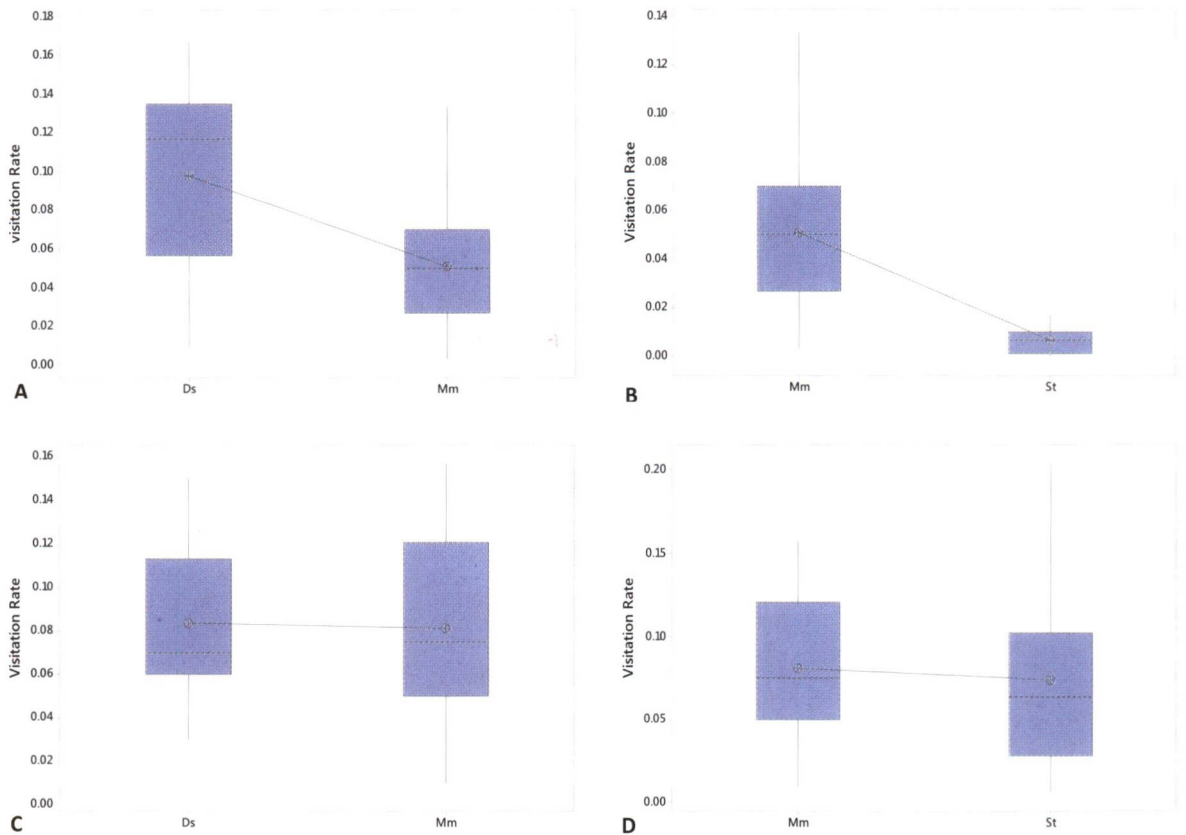


Figure 4. Box plots showing bee visitation rates for invasive and native species at Yagirala site (A,B) and Seethawaka site (C,D): A,C Comparison between *Melastoma malabathricum* (Mm) and *Dillenia suffruticosa* (Ds) B; D: Comparison between *Melastoma malabathricum* and *Spagnetocola trilobata* (St)

DISCUSSION

The dominance of bees in flower visitor assemblages agrees with the open flower morphology of plants (Totland, 1993) and are best known for their role as pollinators (Buchmann, 1985; Karunaratne et al, 2005; Michener, 2007). Pollination of *M.malabaricum* and *Dillenia suffruticosa* is known to occur through Buzz pollinators such as *Xylocopa* (Endress, 1997; Luo et al, 2008). In this study also two species of *Xylocopa* were frequent visitors to these two flowers. Each flower species was visited by species belonging to orders Hymenoptera (Bees, Ants), Diptera, Coleoptera, all of which contains species recognized as pollinators (Kevan & Baker, 1983). Presence of species belonging to these three orders as flower visitors has also been recognized in other studies with similar flower shape (bowl shaped flowers of the studied plant species). It is considered as a generalized flower form and an adaptation to a large number of pollination conditions (Totland, 1993). The reason for lack of visitation by

butterflies in *D.suffruticosa* and *M.malabathricum* may be co-related to the absence of nectar in the flowers of these two plant species (Endress, 1997; Luo *et al*, 2008).

As shown in Figure 2, in this study, more than 50% of bees were shared between *D. suffruticosa* and *M.malabathricum*. At Yagirala in the presence of large showy *D.suffruticosa* significantly reduced the visitation rates of bees to *M.malabathricum*. Reduced visitation rates in the presence of invasive species has been documented by (Moragues & Traveset, 2005). In the other study site (Seethawaka) no significant difference in visitation rates were observed and this may be an indication of lack of competition as recognized by other studies (Moragues & Traveset, 2005; Totland *et al*, 2006). Generally, flowers with large display areas and more rewards (pollen, nectar) tend to attract more visitors (Gibson *et al*, 2012). In this study compared to *S.trilobata* heather two species *D.suffruticosa* and *M.malabathricum* recorded high mean visitation rates of bees. This may be related to the floral size (Ds>Mm>St) and amount of rewards offered by them. The three floral species studied produce large number of flowers year around and may be capable of supporting networks of social bees. Social bees are generalists compared to specialized pollen bees.

This preliminary study identified and compared the insect visitors to invasive alien and native plant species occurring in the same area and highlighted possible effects on pollination supporting the view that native species receive less insect visitors when IAPS co-occur probably due to the better rewards that IAPS offer for insect visitors.

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