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FLORAL VISITORS TO AN INVASIVE PLANT *PRAXELIS CLEMATIDEA* (HIERON. EX KUNTZE) R.M. KING & H. ROB. (ASTERACEAE) IN NORTHEASTERN THAILAND

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ABSTRACT

Pollination is a critical process in the life cycle of flowering plants. *Praxelis clematidea* (Asteraceae) is an invasive plant that has rapidly spread across Thailand and adjacent countries. We investigated the diversity and the proportion of floral visitors of *P. clematidea* on the campus of Khon Kaen University, northeastern Thailand. At least 46 species of floral visitors were observed in the sampling plots. Combined data from casual observations recorded at least 62 species visiting the plant. Lepidoptera was the most diverse group with 17 species observed in our study plots and another 8 species outside. Hymenoptera contributed the most floral visitations (86.5%), among which bees were the most frequent in all areas. The Little Honeybee (*Apis florea*) was the most common species in disturbed areas, while the Giant Honeybee (*A. dorsata*) was commonest in areas adjacent to natural forest. The density of floral heads was not related to the abundance of insect visitors. The high abundance of invasive plants provides a food resource for pollinators but could have a negative impact on the pollination of native or crop plants. This needs further investigation.

Keywords: floral visitor, invasive plant, pollinator, *Praxelis clematidea*, weed

INTRODUCTION

Invasive species present major threats to global biodiversity (Didham *et al.*, 2005; Molnar *et al.*, 2008; Doherty *et al.*, 2016) and also impact the economy and human livelihoods (Pimentel *et al.*, 2005). Most countries, especially lower-income tropical countries with high biodiversity, have little capacity to control invasive species and lack information on their distribution and reproductive success. Many invasive plants are characterized by their broad environmental tolerance and their ability to rapidly adapt to local selective pressures, enabling them to colonize new areas (Sexton *et al.*, 2002). Invasive plants can have great impact on native ecosystems through habitat modification (Didham *et al.*, 2007), competing with native species for resources (Čuda *et al.*, 2015), and also for potential pollinators (Brown & Mitchell, 2001; Hansen *et al.*, 2018).

Invasive plants are poorly described and evaluated in the tropics, especially Southeast Asia (Peh, 2010). Only 23 species have been declared as invasive plants in Thailand, and only seven of these have been verified with evidence of impacts in the Global Register of Introduced and Invasive Species (GRIIS), such as *Chromolaena odorata*, *Eichhornia crassipes* and *Leucaena leucocephala* (Pagad *et al.*, 2018). However, this is likely a gross underestimate considering the

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numbers recorded elsewhere in neighboring countries: 125 species in Cambodia, 112 species in Myanmar, and 36 species in Vietnam have been verified with evidence of impacts (PAGAD ET AL., 2018). Many more species for which no quantitative data exist are potential invasive plants in Thailand and in the region. These include *Praxelis clematidea* (Asteraceae), *Asystasia gangetica* subsp. *micrantha* (Acanthaceae), and *Alternanthera brasiliana* (Amaranthaceae).

P. clematidea is a herbaceous plant native to tropical South America (CORLETT & SHAW, 1995) which had not been recorded outside its native range until 1993/1994 (WATERHOUSE, 2003). It is already now classified as an invasive plant species in other countries, e.g., Florida, USA (GARDNER & WILLIGES, 2015), China (WANG ET AL., 2006; WENZENG & WANG, 2017), Indonesia (WATERHOUSE, 2003) and Australia (CRC WEED MANAGEMENT, 2003). Still relatively little-known, it is reported to have invaded the Malaysian region (WATERHOUSE, 2003) and become a noxious weed elsewhere in Asia and in Oceania (WANG ET AL., 2006). It is not known when it was introduced to Thailand but the plant has rapidly spread throughout the country in many habitats, and is still not listed in the Thai Plant Names last revised edition (POOMA & SUDDEE, 2014). Although it has been widely detected, we found but a single specimen preserved at the largest herbarium in Thailand, The Forest Herbarium (BKF), collected as recently as 1 December 2017 from Ratchaburi Province (specimen checked on 3 November 2020). The first specimen in Khon Kaen University was collected in 2012, during a class assignment.

Lack of information on its distribution, reproductive ecology and potential ecosystem impact has hindered its evaluation as an invasive species. Due to the rapidity of its spread it may pose threats both inside and outside protected areas, in both urban landscapes and agricultural areas such as rice paddies, sugar cane and cassava fields which constitute the three major crops, particularly in Northeast Thailand. One consequence of the invasion of *P. clematidea* and other weeds is an increased application of herbicides which are potentially harmful to non-target organisms (LAUFENBERG ET AL., 2005).

Factors that promote the rapid colonization of invasive plants include their successful reproduction from pollination, seed production, dispersal and germination (ZHANG ET AL., 2021). Understanding its invasive mechanisms, for future management and control, is particularly pressing (WANG ET AL., 2006). Pollination is the initial process for seed production but little data on potential pollinators of this invasive plant have been reported (ZHANG ET AL., 2021; SIMLA ET AL., 2022). Successful self-compatibility of *P. clematidea* in China suggested that the plant is a rapid colonizer of many countries (ZHANG ET AL., 2021). However, the way many invasive Asteraceae produce numerous flowers to attract insect pollinators should benefit the plants by increasing seed quality and genetic diversity in comparison with those that produce autonomous seeds. Here we report on the diversity and proportion of animal pollinators of *P. clematidea* to provide baseline ecological data on the reproductive biology of this invasive plant in Northeast Thailand. Our findings may be useful in ecological monitoring of future invasions and in supporting future studies on the ecology of invasive species in this region.

STUDY AREA AND METHODS

The study was conducted on the Khon Kaen University campus (16° 27´ N, 102° 49´ E) (hereafter KKU). The total area of the campus is approximately 880 ha, comprising various habitats including dry dipterocarp forest, mixed deciduous forest, forest plantations, grazing fields, wetlands, natural and artificial ponds, agricultural fields, academic buildings, residential areas, and parks. Most vegetation on the campus (>50%) is agricultural, interspersed with small natural forest patches. *Praxelis clematidea* (Asteraceae or Compositae) is an annual herbaceous plant that usually spreads out over the ground in continuous patches. Based on our observations in KKU, the plant had already entered the area before 2012 (W. Sankamethawee, personal observation). Mature plants usually grow 10–80 cm tall. The inflorescence capitulum comprises several tiny disc florets, a typical characteristic of subfamily Eupatorieae (McFadyen & Skarratt, 1996). The corolla tube is lilac or bluish-white, and approximately 5–9 mm long.

The surveys were conducted in three locations: 1) Area A, a forest plantation about 6 ha adjacent to a natural dry dipterocarp forest patch. The majority of trees were planted *Dipterocarpus alatus* Roxb. ex G. Don, among scattered stands of native trees including *Erythrophleum succirubrum* Gagnep. and *Dalbergia nigrescens* Kurz.; 2) Area B, a forest plantation of about 2.5 ha adjacent to residential buildings with mixed planted tree species, (*D. alatus*, *Pterocarpus macrocarpus* Kurz, *Dalbergia cochinchinensis* Pierre, and *Azadirachta indica* A. Juss.); and 3) Area C, a small natural dipterocarp forest patch of about 4.3 ha dominated by *Shorea roxburghii* G. Don and *Dipterocarpus obtusifolius* Teijsm. ex Miq.

We observed floral visitors by sampling plots during September–October 2017. Three rectangular plots (1 × 10 m) were placed in each of the three study areas over three survey periods, making a total of 27 plots. The plots in each area were placed at least 20 m apart from each other. We observed floral visitors by slowly walking along one side of each plot on sunny days during 1000–1500 h, adapted from the Pollard Walk method (Pollard, 1977). The average speed for walking was 10 min per plot. The observer stayed at least 2 m away from the plots to avoid disturbance of the insects. We recorded species and number of individual insects that visited or landed on the inflorescence head of *P. clematidea,* assuming that any insect that landed on a flower head was a pollinator (whether or not they transferred pollen). After the surveys, we collected insect specimens found in the study areas for identification and took photographs both outside and inside the plots. If the floral visitors could not be identified to species, we recorded them to the lowest taxonomic level possible (e.g., order, family or genus) and indicated any difference among unique taxa. We confirmed identification of the floral visitors by collecting as many insect specimens as possible and comparing them with specimens available at the Department of Entomology, Faculty of Agriculture, KKU. After each survey was finished, we examined the density of the floral heads by random sampling an area of 1 m^2 within the 10-m^2 plot. Furthermore, we also recorded any floral visitors casually found around the study areas.

We used one-way ANOVA to test if floral density differed among the three sites. The diversity indices, i.e., Dominance (*D*), Simpson index (1-*D*), Shannon index (*H*), Evenness (e^H/S), Equitability (*J*) and species richness were calculated. We compared diversity of insects among sites using diversity *t*-test. We used Pearson Correlation to test whether the abundance of floral heads was related to the visitation rates of different insect groups (bees, other hymenopterans and butterflies). All statistical analyses were performed in program Past (version 3.23) (Hammer *et al.*, 2001). Percent frequency of visits by different floral visitors were recorded, e.g., if one species of floral visitor was detected in all 27 plots its percent frequency of detection was 100% and if detected in 10 plots its percent frequency was 37%.

RESULTS

At least 46 species of invertebrates visited floral heads of *P. clematidea* in the survey plots. From casual observations around the campus, we added a further 16 species outside the sample plots, making a total of 62 species known to visit the floral heads (Table 1). In the sample plots, the visitors represented 8 orders of 2 classes, Insecta (insects) and Arachnida (spiders). Lepidoptera (butterflies and moths) was the most diverse group with 17 species. We also found 11 species of Hymenoptera (ants, bees, and wasps). The other floral visitors were 6 species of Diptera, 5 species of Odonata, 3 species of Orthoptera, 2 species of Hemiptera, one species of Phasmatodea, and one species in the order Araneae.

The average inflorescence density was 702 floral heads/m^2 (range 118–1326 heads; n = 27; 270 m^2). The density of floral heads was not different among the three sites ($F = 0.968$, $df = 2$, $p = 0.394$). There was a total of 332 floral visitations (range 3–24 visitations/plot) in 27 surveyed plots by those 46 species. The density of floral heads was not related to the visitation rates of any groups of visitors (r = -0.176, p = 0.381 for Hymenopterans, and r = -0.299, p = 0.130 for butterflies).

Among all floral visitors, hymenopterans contributed the most flower visitations (86.45% of all observations), while butterflies and hoverflies contributed 5.7% and 3.0%, respectively. Bees *Apis* spp. (Figs. 2, 4) were the most frequently observed floral visitors, and were found in all surveyed plots (frequency of detection of 100%), while the frequency of detection for other groups was less than 40%. Bees accounted for 88% of hymenopterans which contributed 75.9% of all floral visitations (Fig. 1; Table 3). The abundance of bees was not related to the density of floral heads (r = -0.157, p = 0.433). The three common species of bees (*Apis* spp.) were more abundant in the natural forest patch (area C). The Little Honeybee (*A. florae*) was the most abundant in the disturbed areas while the Giant Honeybee (*A. dorsata*) was most common in the area adjacent to the natural forest. Lepidopterans were the most diverse group observed in our site, but they contributed only 5.7% of total floral visits (Table 3). Although flies (Diptera) were one of the most diverse groups in this study, they contributed only 3.0% of all floral visitations (Figs. 1, 3; Table 3).

The highest species richness of floral visitors was found in the forest plantation adjacent to the natural dry dipterocarp forest (Area A) with 24 species of 6 orders observed. The forest plantation adjacent to residential buildings (Area B) had the lowest species richness (17 species) but had the highest diversity indices (Shannon H = 2.194, Table 2). Although the natural dipterocarp forest patch (Area C) had more individual pollinators visiting it, it had a significantly lower diversity index than the other two areas (Table 2). The density of floral heads was not different among sites, but the vegetation structure and adjacent landscape of these three areas seemed to influence the species richness of insect pollinators. The least disturbed area adjacent to the natural forest (A) had the highest species richness (24 species). Areas B and C, adjacent to the buildings, had similar numbers of species (17 and 18, respectively). Area C had the lowest diversity index and evenness index because the dominant species, Little Honeybee (*Apis florea*), contributed 41.3% of all visitors observed (Fig. 2).

Table 1. The number of pollinators of *Praxelis clematidea* observed during September–October 2017 in Khon Kaen University. Area A is a forest plantation adjacent to residential buildings, Area B is forest plantation adjacent to a dry dipterocarp forest patch, and Area C is natural dry dipterocarp forest patch. The right column indicates those insects observed casually outside the sampling plots regardless of number of visits.

No.	Taxa	Area			Frequency (%)	Casual observations
		A	B	C		
Order Araneae						
	Family Oxyopidae					
1	*Oxyopes javanus*	2	0	0	7	
Order Coleoptera						
	Family Buprestidae					
2	*Sternocera aequisignata*	0	0	0	0	√
Order Diptera						
	Family Conopidae					
3	Thick-Headed Fly	0	0	0	0	√
	Family Syrphidae					
4	Hoverfly 1	0	2	0	7	√
5	Hoverfly 2	2	0	0	7	
6	Hoverfly 3	0	1	0	4	
7	Hoverfly 6	0	0	0	0	√
	Family Tabanidae					
8	Hoverfly 4	0	0	2	7	
9	Hoverfly 5	0	2	0	7	
10	Robber Fly	1	0	0	4	
Order Hemiptera						
	Family Alydidae					
11	Broad-Headed Bugs	0	0	0	0	√
12	*Leptocorisa* sp.	1	0	0	4	
	Family Reduviidae					
13	*Valentia compressipes*	0	0	2	7	√
Order Hymenoptera						
	Family Ammophilinae					
14	*Ammophila* sp.	2	1	0	11	
	Family Apidae					
15	*Apis cerana*	17	12	34	100	√
16	*Apis dorsata*	16	10	23	100	√
17	*Apis florea*	44	22	71	100	√

Table 1 (continued).

No.	Taxa	Area			Frequency (%)	Casual observations
		A	B	C		
	Family Braconidae					
18	Wasp	0	0	1	4	
	Family Formicidae					
19	*Camponotus* sp.	9	5	5	33	√
20	*Diacamma* sp.	4	3	2	26	√
	Family Megachilidae					
21	Mason Bee 1	0	2	0	7	
22	Mason Bee 2	0	1	0	4	
	Family Sphecidae					
23	Digger Wasp 1	0	1	0	4	√
24	Digger Wasp 2	0	0	2	7	
Order Lepidoptera						
25	Moth	1	0	0	4	
	Family Hesperiidae					
26	*Ampittia dioscorides*	0	0	0	0	√
27	*Gerosis bhagava*	0	1	0	4	√
28	*Iambrix salsala*	0	0	0	0	√
29	*Pelopidas mathias*	1	0	0	4	
30	*Potanthus sita*	0	0	1	4	√
31	*Spialia galba*	0	0	1	4	
32	*Telicota augias*	0	0	0	0	√
33	Unknown Hesperiidae	0	0	0	0	√
	Family Lycaenidae					
34	*Anthene lycaenina*	0	0	0	0	√
35	*Castalius rosimon*	1	0	0	4	√
36	*Rapala airbus*	1	0	0	4	√
37	*Zizina otis*	0	0	0	0	√
	Family Nymphalidae					
38	*Danaus chrysippus*	1	0	0	4	√
39	*Danaus genutia*	1	0	0	4	√
40	*Euploea core*	1	0	0	4	√
41	*Hypolimnas bolina*	0	0	1	4	√
42	*Hypolimnas misippus*	0	0	1	4	√
43	*Junoia almanac*	1	0	0	4	√

Table 1 (continued).

No.	Taxa	Area			Frequency (%)	Casual observations
		A	B	C		
44	*Junonia atlites*	0	0	0	0	√
45	*Ypthima baldus*	1	1	0	7	√
46	*Ypthima huebneri*	1	0	0	4	√
	Family Papilionidae					
47	*Pachiliopta aristolochiae*	0	1	1	7	√
	Family Pieridae					
48	*Catopsilia pomona*	1	0	0	4	√
49	*Leptosia nina*	0	0	0	0	√
Order Odonata						
	Family Coenagrionidae					
50	*Agriocnemis nana*	1	0	0	4	√
	Family Libellulidae					
51	*Aethriamanta aethra*	0	0	1	4	
52	*Diplacodes trivialis*	0	0	1	4	
53	*Neurothemis intermedia*	1	0	0	4	√
54	*Neurothemis tullia*	1	0	0	4	√
55	*Potamarcha congener*	0	0	0	0	√
56	*Rhyothemis variegate*	0	0	0	0	√
	Family Lindeniidae					
57	*Ictinogomphus decoratus*	0	0	0	0	√
Order Orthoptera						
	Family Acrididae					
58	*Hieroglyphus banian*	0	0	1	4	√
59	*Phlaeoba infumata*	0	2	0	7	√
	Family Gryllidae					
60	*Trigonidium cicindeloides*	0	1	0	4	
	Family Phasmatidae					
61	*Ramulus siamensis*	0	0	2	7	
	Family Pyrgomorphidae					
62	*Tagasta marginella*	0	0	0	0	√
	Total individuals per plot	**112**	**68**	**152**	**332**	
	Total species per plot	**24**	**17**	**18**		

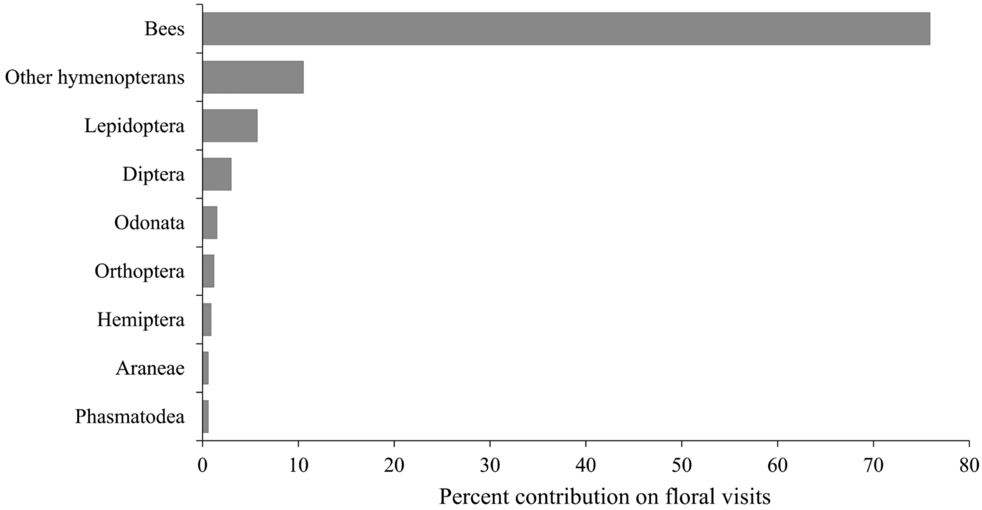

Figure 1. The percentage of floral visitors of *Praxelis clematidea* observed at the survey plots. The order Hymenoptera is divided into 2 groups, viz. bees, and other hymenopterans.

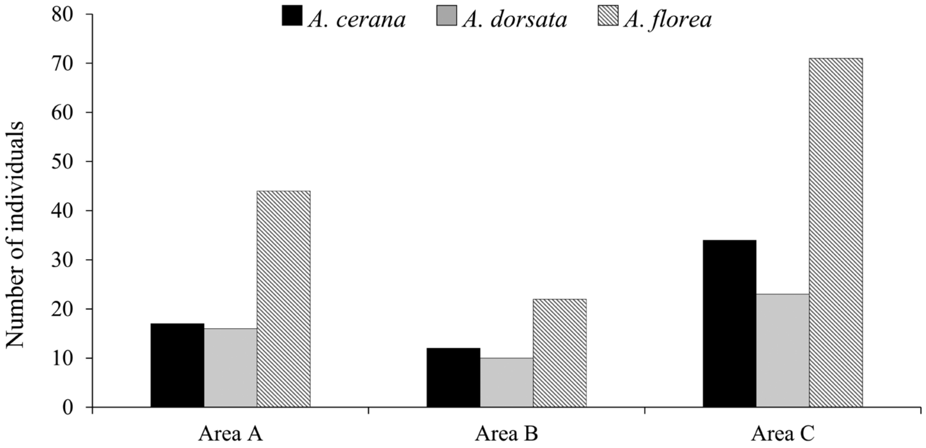

Figure 2. Number of the most common bees (*Apis* spp.) as floral visitors of *Praxelis clematidea* observed at the survey plots in three different areas.

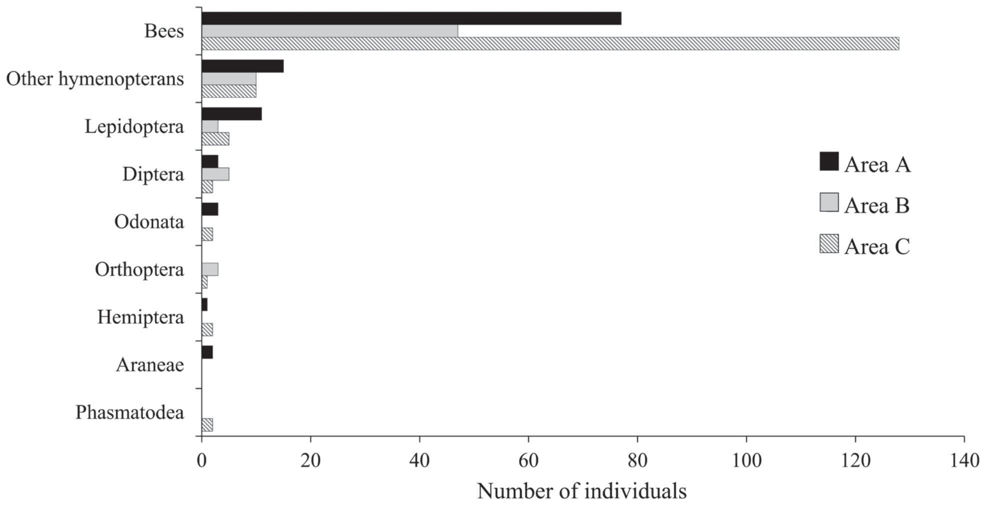

Figure 3. Number of floral visitations by different groups of insects at *Praxelis clematidea* inflorescences. The order Hymenoptera is divided into two groups, viz. bees, and other hymenopterans.

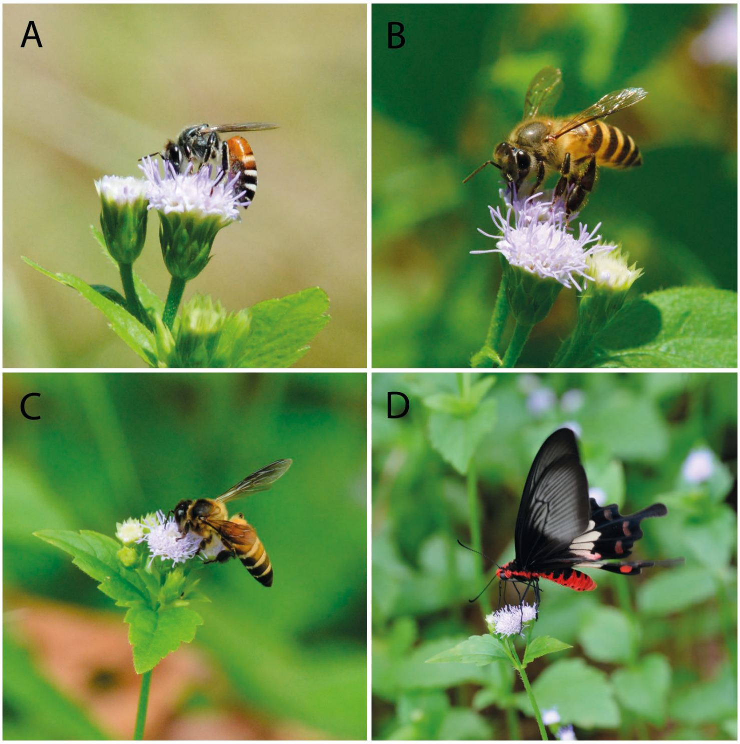

Figure 4. The top three most common floral visitors of *Praxelis clematidea* observed at the survey plots: *Apis florea* (A); *A. cerana* (B); *A. dorsata* (C), and one of the most common butterflies from casual observations, *Pachiliopta aristolochiae* (D). Photographs by Kornkanok Wongwila.

Table 2. Diversity indices of pollinators that visited *Praxelis clematidea* in 27 sampling plots with comparisons of diversity using *t*-tests among sites.

Diversity indices	Area		
	A	B	C
Species richness	24	17	18
Individuals	112	68	152
Simpson (1-*D*)	0.79	0.83	0.71
Shannon (*H*)	2.14	2.19	1.67
Evenness (*e^H/S*)	0.36	0.53	0.30
Equitability (*J*)	0.67	0.77	0.58

Statistical tests	Shannon index		Simpson index	
	t	*p*	*t*	*p*
Diversity *t*-test A vs B	-0.2725	0.7856	0.8949	0.3721
Diversity *t*-test A vs C	2.8184	0.0052*	-2.0736	0.0391*
Diversity *t*-test B vs C	3.0266	0.0029*	-2.9915	0.0032*

* = $p < 0.05$

Table 3. Number of floral visitations by different groups of insects at *Praxelis clematidea* inflorescences.

Pollinators (order)	Number of individual pollinators			
	Area A	Area B	Area C	Overall
Hymenoptera	92 (27.71%)	57 (17.17%)	138 (41.57%)	287 (86.45%)
Bees	77 (23.19%)	47 (14.16%)	128 (84.21%)	252 (75.90%)
Other hymenopterans	15 (4.52%)	10 (3.01%)	10 (3.01%)	35 (10.54%)
Lepidoptera	11 (3.31%)	3 (0.90%)	5 (1.51%)	19 (5.72%)
Diptera	3 (0.90%)	5 (1.51%)	2 (0.60%)	10 (3.01%)
Odonata	3 (0.90%)	0	2 (0.60%)	5 (1.51%)
Orthoptera	0	3 (0.90%)	1 (0.60%)	4 (1.20%)
Hemiptera	1 (0.30%)	0	2 (0.60%)	3 (0.90%)
Phasmatodea	0	0	2 (0.60%)	2 (0.60%)
Araneae	2 (0.60%)	0	0	2 (0.60%)

DISCUSSION

This was a preliminary study conducted in a small area for a relatively short period of time. The 62 floral visitor species are likely to be only a small proportion of all possible visitors of *P. clematidea* in the region. The results suggest that this plant is a generalist that has no specific pollinator, an important characteristic of invasive species that have high competitive ability to colonize new ecosystems (Simla *et al.*, 2022). A high diversity of potential pollinators would be expected to promote the reproductive success of this plant in a wide range of habitats.

The results from our study, both from the plots and casual observations, regardless of efficiency or abundance, showed that insects were the most important floral visitors of *P. clematidea* in our suburban study area. Our results represent typical floral visitors of angiosperms worldwide where hymenopterans play the most important role as pollinators. Bees (*Apis* spp.) contributed almost 90% of floral visitations by all hymenopterans in this area. Butterflies were the most diverse floral visitors and their communities vary greatly in space and time. Thus, monitoring the year-round cycle of the reproductive ecology of invasive plants will be useful in providing the information of how plant-insect interactions change in spatio-temporal scales. We did not examine the pollen loads of the insects that visited the floral heads, but assumed that the majority of hymenopterans and butterflies were potential pollinators for most flowering plants, although their pollination efficiency may vary among taxa (Schemske & Horvits, 1984).

The Giant Honeybee *A. dorsata* was most common in the area adjacent to the natural forest, but the Little Honeybee *A. florea* was more tolerant of the urban landscapes than the others. Bees are the most important pollinators for many flowering plants (Kremen *et al.*, 2002; Greenleaf & Kreman, 2006), but their population trend worldwide is declining (Potts *et al.*, 2010). Our finding that bees were the most common floral visitors of the noxious weed *P. clematidea* suggests that native plants and crop plants may be affected both from pollinator declines and by competition for declining potential pollinators.

At least eight additional species of butterflies were recorded from casual observations, suggesting that there are likely many more potential butterfly pollinators of *P. clematidea*. Most of the pollinators found in our study (Hymenoptera, Lepidoptera, Hemiptera, Coleoptera, and Diptera) are common floral visitors of Asteraceae elsewhere. However, the dominant group of pollinators may vary among plant species and sites. For example, bees accounted for 97% of floral visits of *Heterotheca subaxillaris* (Asteraceae) in Texas (Olsen, 1996) and bees were the most diverse and abundant group visiting *Mikania urticifolia* (Asteraceae) in Argentina (Cerana, 2004). In addition, 67–93% of visitations to three species of *Bidens* (Asteraceae) in Brazil were by hymenopterans (Grombone-Guaratini *et al.*, 2004).

In this study, hoverflies contributed only 3.0% of all floral visitations, which was relatively similar to that of butterflies (5.8%). Hoverflies are known to be an important group of pollinators elsewhere (Ssymank *et al.*, 2008), but have often been overlooked (Orford *et al.*, 2015). In North America, for example, flies are among the most common floral visitors (Kearns, 2001; Kevan & Baker, 1983; Larson *et al.*, 2001). A study in northern Thailand reported at least 21 hoverfly species visiting 26 different plant species, while 54 other fly species were also reported as flower visitors (Tasen & Malaipan, 2013). Hoverflies are among the most challenging groups to identify in the field as they look similar to bees, which can lead to their misidentification. Thus, specimens must be collected for identification in studies at community and landscape levels.

A few species of Orthoptera (grasshoppers and crickets) were thought to be incidental visitors to the flowers in our study, but TAN *ET AL*. (2017) suggested that orthopterans are overlooked floral visitors in Southeast Asia, as they reported at least 41 species visiting 35 different flowering plants. However, in this study, these insects probably merely landed on the floral heads or accidentally perched on them; thus, their pollination efficiency was probably far less than that of true pollinators (bees and butterflies) (ZYCH *ET AL*., 2013). Birds are also known to be pollinators of Asteraceae (CERANA, 2004), but we did not observe any bird visiting *P. clematidea* flowers during our study. *P. clematidea* has a low stature and small flower heads (<1 cm), whereas most bird-pollinated flowers are showy and bright-colored (usually red or orange) and are displayed higher off the ground (FENSTER *ET AL*., 2004).

The recent study by ZHANG *ET AL*. (2021) revealed that *P. clematidea* is an autonomous plant that can be self-compatible, but cross pollination in any flowering plants is still important in promoting genetic diversity and high seed quality, which increases plant fitness (MAMOOD *ET AL*., 1990; HIRAYAMA *ET AL*., 2005). Autonomous seed production may facilitate the invasiveness of the species by increasing seed crops, but this reproductive strategy can result in lower seed quality and fitness of the plant (CHAPMAN & ABBOTT, 2009). The abundance of flowers in an invasive plant patch attracts numerous insect pollinators to the area, as a pollination hub (SIMLA *ET AL*., 2022), and may also attract potential competitors of pollinators of native plants.

This study has collected information on the basic reproductive strategy of an invasive plant in Thailand and Southeast Asia. Many more studies on invasive plants are needed in Thailand and the region to provide scientific data to support biodiversity conservation. The effects of invasive plants on native species and economic crops should be investigated to reveal how invasive plants affect local pollination networks (SIMLA *ET AL*., 2022), particularly those involving pollination of native plants and important food crops (BROWN & MITCHELL, 2001; PERRE *ET AL*., 2011; HANSEN *ET AL*., 2018). Furthermore, studying the effects of invasive plants on the community structure of insect pollinators in different land use types would be instructive.

The basic life history data revealed in this study will provide useful baseline information for further studies on the reproductive ecology of invasive plants and other noxious weeds. As *P. clematidea* and many other invasive species in the region are already widespread in many ecosystems, the effects of these plants on native species and economic crops should be investigated to show how invasive plants affect local pollination networks.

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