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Importance of Carpenter Bee, *Xylocopa varipuncta* (Hymenoptera: Apidae) as Pollination Agent for Mangrove Community of Setiu Wetlands, Terengganu, Malaysia

(Kepentingan Lebah Tukang, *Xylocopa varipuncta* (Hymenoptera: Apidae) Sebagai Agen Pendebungaan untuk Komuniti Pokok Bakau di Tanah Bencah Setiu, Terengganu, Malaysia)

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ABSTRACT

A study on the importance of Xylocopa varipuncta *(Hymenoptera: Apidae) as pollination agent was conducted at the Setiu Mangrove Forest, Terengganu from September to December 2010. The objective of this study was to identify the pollens collected by carpenter bees (*X. varipuncta*) in the mangrove community of Setiu Wetlands. A total of 35 types of pollens were collected from the body of* X. varipuncta *and only 10 types of the pollens were successfully identified. The identified pollens were of* Avicennia alba, Lumnitzera racemosa, Sonneratia caseolaris, S. ovata *and* Rhizophora apiculata *from exclusive mangroves, while* Suregada multiflora, Melaleuca cajuputi, Derris trifoliata, Acacia auriculiformis *and* Hibiscus tiliaceus *were from non-exclusive mangroves*. Melaleuca cajuputi *was the highest number of pollen carried by* X. varipuncta. *This study showed that* X. varipuncta *is an important pollen carrier in the mangrove community of Setiu Wetlands, Terengganu.*

Keywords: Mangroves; pollination agent; Setiu Wetlands; Xylocopa varipuncta

ABSTRAK

Satu kajian tentang kepentingan Xylocopa varipuncta *(Hymenoptera: Apidae) sebagai agen pendebungaan telah dijalankan di hutan paya bakau Setiu, Terengganu dari September hingga Disember 2010. Objektif kajian ini adalah untuk mengenal pasti debunga yang dibawa oleh* X. varipuncta *di komuniti pokok bakau Tanah Bencah Setiu, Terengganu. Sejumlah 35 jenis debunga telah dikutip daripada badan* X. varipuncta *dan hanya 10 jenis dapat dikenal pasti. Debunga yang dikenal pasti adalah* Avicennia alba, Lumnitzera racemosa, Sonneratia caseolaris, S. ovata *dan* Rhizophora apiculata *daripada pokok bakau eksklusif, sementara* Suregada multiflora, Melaleuca cajuputi, Derris trifoliata, Acacia *auriculiformis dan* Hibiscus tiliaceus *adalah daripada pokok bakau bukan eksklusif. Debunga* Melaleuca cajuputi *adalah yang tertinggi dibawa oleh* X. varipuncta. *Kajian ini telah menunjukkan bahawa* X. varipuncta *adalah pembawa debunga yang penting bagi pokok bakau di Tanah Bencah Setiu, Terengganu.*

Kata kunci: Agen pendebungaan; bakau; Tanah Bencah Setiu; Xylocopa varipuncta

INTRODUCTION

Mangroves, once neglected plants, are now gaining great importance, such as protecting shorelines from damaging storm and hurricane winds, waves and floods. Mangrove forests play an important role in maintaining water quality and clarity, filtering pollutants and trapping sediments originating from land. Mangroves also are home to a variety of animals, such as bats, the Proboscis Monkeys, snakes, otters and other animals.

The relationship between animals and mangrove forests is very unique, where the two are interdependent to each other. One of the functions of animals is they are an important agent for pollination of mangrove plants. Various researchers suggested that bats and birds are the main pollination agents for mangroves (Bestmann et al. 1997; Knudsen & Tollsten 1995) besides insects, because most bats live in mangroves as their habitat (Bordignon 2006).

Although there is little information on insect pollination as the agent of mangrove area, it is not possible to point out that insects are one of the most effective pollination agents in mangrove forest. According to Tomlinson et al. (1978), mangrove forests are visited by a variety of day-active insects such as bees, butterflies and day-active moths. There is also some evidences that show honey bees, *Apis mellifera* is the common visitor of *Avicennia marina* (Clarke & Myerscought 1991). Bees can efficiently transfer pollen among different plant individuals of the same species. The cross pollination that occurs can make healthier and more genetically diverse plant populations. As a result, the diversity in mangrove forests can be maintained which is indirectly responsible for the environmental consistency, community persistence and community or ecosystem disturbance (Daniel 2008).

To date, there is very few publication about insect as the pollinator of mangrove plants specifically in Malaysia. Tomlinson et al. (1978) found that *Lumnitzera littorea* is pollinated predominantly by honeyeaters, whereas *L. racemosa* is visited by a variety of day-active insects such as wasps, bees, butterflies, and day-active moths. Another study done by Clarke and Myerscough (1991) found that the flowers of *Avicennia marina* were visited by ants, wasps, bugs, flies, bee flies, cantherid beetles and moths. They found that the most common visitor was the honey bees (*Apis mellifera*).

As little is known about the importance of carpenter bee, *Xylocopa varipuncta* in mangrove forest, this study is intended to investigate whether *X. varipuncta* is one of the pollination agents of mangrove community in Setiu Wetlands, Terengganu. It is hoped that findings from this study will provide some information on the important role played by *X. varipuncta* as a pollination agent in the mangrove forests of Malaysia.

Materials and Methods

Study Area

The study was conducted at Setiu Wetlands, in the Terengganu state, east coast of Peninsular Malaysia. The Setiu Wetlands (N 05° 40' 38.6", E 102° 43' 03.2") is consisted of Setiu River and lagoon with numerous islands. The lagoon drains into the South China Sea via an opening at Kuala Setiu. Approximately 21 species of mangroves can be found in Setiu Wetlands, which include of *Sonneratia caseolaris, S. alba, S. ovata, Nypa fruticans, Avicennia marina, Ceriops decandra,* and *Lumnitzera racemosa* (Tamblyn et al. 2006).

Reference Sample of Pollens

Mangrove pollens were collected directly from the mangrove plants in the study area and in mangrove area of Universiti Malaysia Terengganu (UMT) as a reference to compare with the pollen type that was identified from the body of *X. varipuncta*. Flower bud was plucked carefully and preserved in vial containing 70% ethanol. Pollens for reference sample were prepared in the slide using micropipettes and cover slide. The slide was observed under a Moticam 1300 light microscope (40 × magnification). The pollen image was captured and the length and width of the pollen was measured.

Sampling of *Xylocopa varipuncta*

Xylocopa varipuncta were collected using an insect net at three different sites in the Setiu Wetlands. *Xylocopa varipuncta* were then preserved in killing jars contained with chloroform to stun them quickly and kill them. Each killing jar was labeled with the name of the foraging, date collected, area collected and time collected. Later, the *X. varipuncta* in killing jars were sent to the laboratory for further analysis.

Pollens Collection from *Xylocopa varipuncta* and Identification of Pollens

The whole body of *X. varipuncta* was swabbed with cotton bud and the cotton bud was preserved in the properly labeled vial which containing 70% of ethanol. Using the micropipette, 15 μm of the preserved pollens in the vial was transferred to the slide and was covered by cover slide. Each vial has 10 replicates of slides in order to provide representative coverage of pollens collected by each individual. The slide was observed under a Moticam 1300 light microscope (40 × magnification). The pollen image was then captured and the length and width of pollen were measured. The pollen was identified by comparing it with the reference slides.

Data Analysis

Analysis of Variance (ANOVA) was used to evaluate the differences of total number and total species of identified pollens carried by each individual of *X. varipuncta* (SPSS 2008). Two-way cluster analysis using Sorenson's Coefficient method was used to sort *X. varipuncta* ($N = 16$ individuals) into groups to reveal the degree of association between individuals and species pollens collected from their body (McCune & Mefford 2006).

Results and Discussion

Overall, 12 samples of pollens were collected as reference samples and were compared with the pollen types from the body of *X. varipuncta*. The reference samples which consisted of six species of exclusive mangroves were Berembang (*Sonneratia caseolaris*), Api-api putih (*Avicennia alba*), Perepat (*Sonneratia ovata*), Nipah (*Nypa fruticans*), Bakau minyak (*Rhizophora apiculata*) and Teruntum Puteh (*Lumnitzera racemosa*) (Figure 1). For non-exclusive mangroves, they were Ketapang (*Terminalia catappa*), Limau hantu (*Suregada multiflora*), Gelam (*Melaleuca cajuputi*), Tuba Laut (*Derris trifoliata*), Akasia kuning (*Acacia auriculiformis*) and Bebaru (*Hibiscus tiliaceus*) (Figure 2).

There were 33 individuals of *X. varipuncta* captured at three sites in Setiu Wetlands. Site 1 collected the highest number of *X. varipuncta* with 18 individuals, followed by Site 3 with 13 individuals, and Site 2 with only 2 individuals. Out of that, only 16 individuals were selected to represent the sample size of pollens carried by each *X. varipuncta* in Setiu Wetlands. The highest number of pollens was carried by individual 9 which were 2966 pollens, while the lowest was 25 pollens by individual 11. The highest species of pollens were 16 species carried by individual 14 at Site 3, while individual 11 carried the lowest species of pollens which was 4 species at Site 2. There were significant differences in the total number of pollens ($F = 6.438$, $p<0.05$) and total species of pollens ($F = 9.247$, $p<0.05$) collected by each individual of *X. varipuncta*. Least Significant Analysis (LSD) shows that only individual 9 was significantly different compared with other individuals.

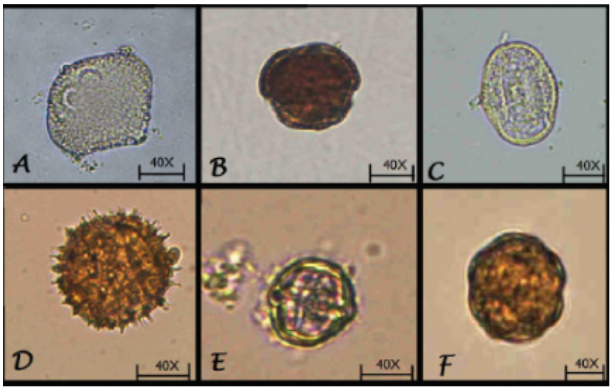

FIGURE 1. Reference samples of pollens from exclusive mangroves. (A: *Sonneratia caseolaris,* B: *Avicennia alba,* C: *Sonneratia ovata,* D: *Nypa fruticans,* E: *Rhizophora apiculata,* F: *Lumnitzera racemosa*)

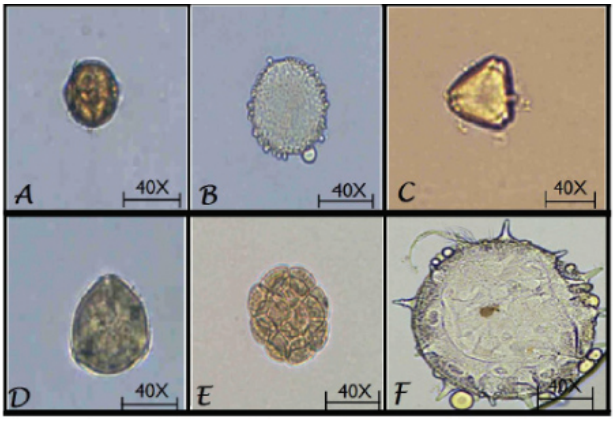

FIGURE 2. Reference samples of pollens from non-exclusive mangroves. (A: *Terminalia catappa,* B: *Suregade multiflora,* C: *Melaleuca cajuputi,* D: *Derris trifoliata,* E: *Acacia auriculiformis,* F: *Hibiscus tiliaceus*)

Interestingly, 35 types of pollens were collected and identified from the bodies of *X. varipuncta*. However, only 10 types of pollens were successfully identified. They were *Avicennia alba*, *Lumnitzera racamosa, Sonneratia caseolaris, S. ovata,* and *Rhizophora apiculata* from exclusive mangroves, while *Suregada multiflora, Melaleuca cajuputi*, *Derris trifoliata*, *Acacia auriculiformis* and *Hibiscus tiliaceus* were from non-exclusive mangroves. Twenty five pollens could not be identified and will be investigated further.

Melaleuca cajuputi (66.33%) was the highest pollens collected, whereas the lowest was *Hibiscus tiliaceus* (0.02%). The highest number of *Melaleuca cajuputi* pollens could be possibly due to their long flowering season during our sampling days. The percentage of unidentified pollens was 28.45%, which comprised of 25 types of unidentified pollen species (Figure 3). Two-way cluster analysis shows that all individuals of *X. varipuncta* from each study site carried the pollen of *Melaleuca cajuputi* and one of unidentified pollen, named

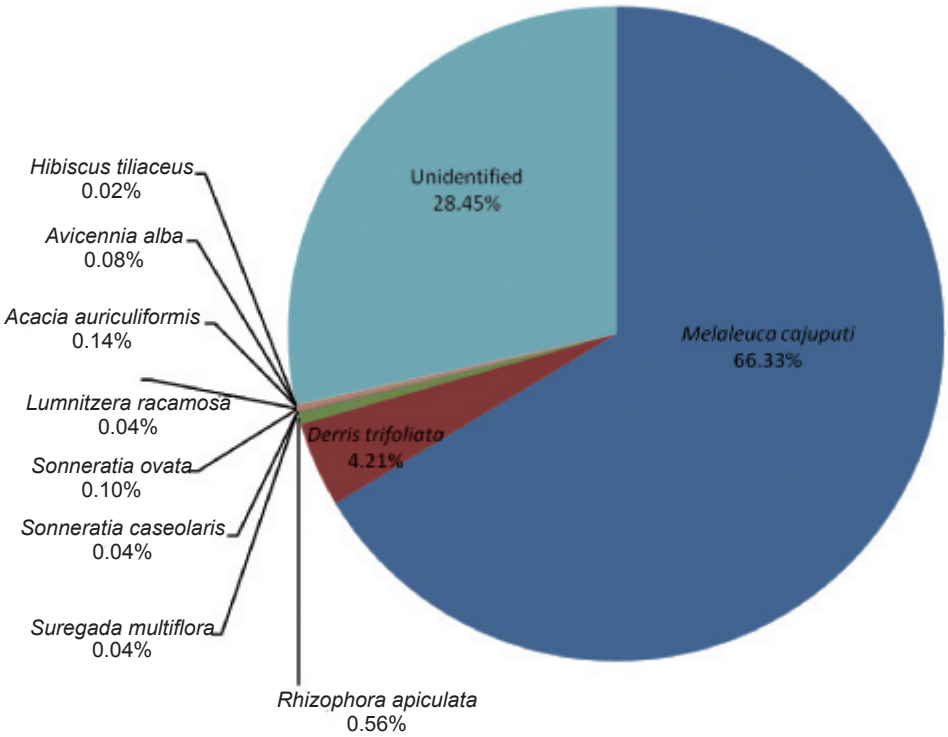

FIGURE 3. Composition and percentage of pollens carried by *Xylocopa varipuncta* at three different study sites in Setiu Wetlands

as Sp. A (Figure 4). The most interesting outcome from this analysis is that there were certain individuals carried certain species of pollen at certain site. For example, pollen of *Hibiscus tiliaceus* was only found on individual 9 at Site 1 and unidentified pollens of Sp. F and Sp. M were only found on individual 10.

In this study, Site 1 and Site 3 contributed to the highest captured individuals of *X. varipuncta* compared to Site 2. This could be due to these locations which are nearer with the river compared with Site 2. Bees were more common visitors to the trees close to the water, although bees may in fact fly a considerable distance to obtain water (Beekman & Ratnieks 2000). Besides that, Site 1 and Site 3 have not been disturbed by humans, while Site 2 was considered as disturbed area where agriculture and aquaculture activities could be found there. Many of the trees have been cut down, and as a consequence, the flowers in Site 2 were decreasing.

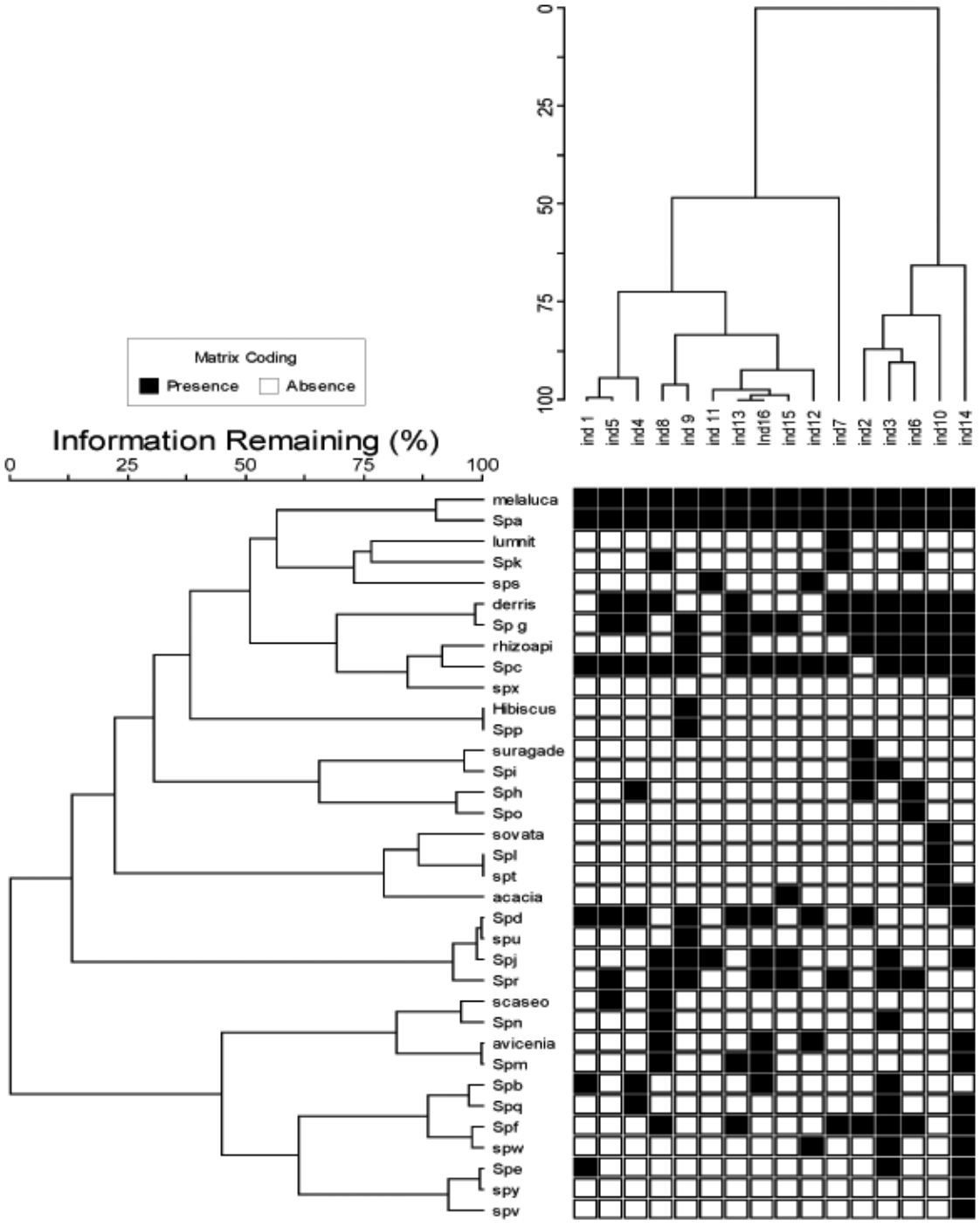

FIGURE 4. Two-way cluster analysis showing the degree of association between individuals and pollens species collected from the bodies of *Xylocopa varipuncta* (N = 16 individuals)

Xylocopa varipuncta require ample supply of flowers in their habitat, since this is their food source.

According to Barbier (1970), bees usually collect many different types of pollen to achieve a nutritional balance. Pollen of *Melaleuca cajuputi* is the highest carried by *X. varipuncta* at each site. Even though not every site has *Melaleuca cajuputi, X. varipuncta* can fly as far as 8 to 13 km from their nest to reach food or water (Sammataro & Avitabile 1998). Saberioon et al. (2009) stated that *Melaleuca cajuputi* trees are major sources of nectar and pollen for giant honeybees. In addition, *Melaleuca cajuputi* has strong flavour and weak density of honey (Saberioon et al. 2009). However, the trunks and branches of the *Melaleuca* trees are almost upright and the barks are dry and loose that they are unsuitable as nesting supports for bees. Therefore, other flat barked trees with sloping branches in the surrounding area of the *Melaleuca* forest are selected as nesting supports for the bees' colonies (Saberioon et al. 2009). Normally, bees prefer nesting places in trees rather than in an open landscape and the habitats that have an abundant supply of suitable flowering plants, such as meadows, open wooded areas and gardens. They can survive in grasslands, deserts and wetlands if there are sufficient water, food and shelter. They need cavities (in hollow trees) to nest in (Milne & Milne 2000). Most often the bees prefer to build their combs or nests high in trees instead of close to the ground, but bees nests can be found everywhere in a tree.

The characteristics of honey at *Acacia auriculiformis* flower are similar to *Melaleuca cajuputi,* which are the major sources for giant honeybees. Many researchers found that *Sonneratia* spp. are pollinated by bats (Azuma et al. 2002; Fleming et al. 2009). The flowers of *Sonneratia* spp. which open during the early evening produce large amount of nectar (Tomlinson 1986). Bats are usually out looking for food at night and the bees are only foraging during daylight on a sunny day. However from this study, *X. varipuncta* was found to carry two species of *Sonneratia*. There were *Sonneratia ovata* and *S. caseolaris*. In a similar study, Yao et al. (2006) found that *Sonneratia* spp. became the plant of first choice for honeybees during their flowering season. Open perianths of *Sonneratia* spp. make it easier for the bees to gather pollens from *Sonneratia* spp. (Yao et al. 2006). According to Lowenfeld and Klekowski (1992), *Rhizophora* spp. is primarily self-pollinated. Interestingly, in this study, *X. varipuncta* was also found to carry the pollen of *Rhizophora apiculata*.

The total number of pollens carried by *X. varipuncta* was different among the individuals. This could be probably due to the different body sizes of *X. varipuncta*. Individual 9 carried the highest number of pollens because it has a large body size (43 mm) compared with other individuals (mean size of *X. varipuncta* was 36.60 $\pm$ 0.25 mm). The larger body size of individual increases the surface area of body, which increase the number of pollens that stick on the body of *X. varipuncta*. Besides that, environmental factors also influence the number of pollens carried by *X. varipuncta*. Usually, the environmental factors such as temperature, light intensity, humidity and other affect the collection activity of bees (Yao et al. 2006). The bees become slow and are less likely to venture out collecting pollens during high humidity (Yao et al. 2006).

The total number of pollens carried by *X. varipuncta* did not influence the total species of pollens that were carried by *X. varipuncta*. It probably depends on how many trees are perched by *X. varipuncta*. When *X. varipuncta* landed on the flower, the pollens will stick to their hairy body. *Xylocopa varipuncta* also have a pollen basket (corbicula) on their hind legs (Milne & Milne 2000). The corbicula is a polished concavity surrounded by a fringe of hairs, into which the pollen is placed. Most other bees possess a structure called the scopa, which is similar in function, but is a dense mass of branched hairs into which pollen is pressed, with pollen grains held in place in the narrow spaces between the hairs (Milne & Milne 2000).

A bee will moisten the forelegs with a protruding tongue and brushes the pollen that has been collected on head, body and forward appendages to the hind legs. The pollen will be transferred to the pollen comb on the hind legs and then combed, pressed, compacted, and transferred to the corbicula on the outside surface of the tibia of the hind legs. A single hair functions as a pin that secures the middle of the pollen load. Honey or nectar is used to moisten the dry pollen. The mixing of the pollen with nectar or honey changes the colour of the pollen. The colour of the pollen can identify the pollen source (Dorothy 1952). Other factors that affect the total pollen and total species of pollens carried by *X. varipuncta* are probably the productivity, length of the flowering period and the area of the distribution (Yao et al. 2006).

Conclusion

This study showed that the carpenter bees (*X. varipuncta*) collected 35 species of pollens in the mangrove forest of Setiu Wetlands. Out of 35 species of pollens, only 10 types of the pollens were successfully identified. They were *Avicennia alba*, *Lumnitzera racemosa, Sonneratia caseolaris, S. ovata,* and *Rhizophora apiculata* from exclusive mangroves, while *Suregada multiflora, Melaleuca cajuputi*, *Derris trifoliata*, *Acacia auriculiformis* and *Hibiscus tiliaceus* were from non-exclusive mangroves. *Melaleuca cajuputi* was the highest number of pollen carried by *X. varipuncta*. Therefore, this study showed that the carpenter bees, *X. varipuncta* plays an important role as pollens carrier of mangrove forest, besides bats, birds and honey bees. Further study is suggested to determine the unidentified pollens in order to understand the function of *X. varipuncta* as important pollination agent in mangrove forests of Malaysia.

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