Pollination services support for agriculture productions values

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Abstract. Pollination is one of ecosystem services provided by tropical forest as addressed in The Millennium Ecosystem Assessment. Roughly, two-third of the world’s agriculture species cultivation required pollination. Studies shows that 70% of tropical crops seem to have at least one variety for which production is improved by animal pollinators. Most common pollinators live naturally in the ecosystem known as wild pollinators. The objective of this study was to quantify the economic value of pollination services by wild pollinators of Gunung Tebu Forest Reserves, Besut, Terengganu. Agricultural data was obtained from Department of Agriculture Terengganu. Data incorporated the list of farmers/villages, types of crops planted, annual area planted (ha), annual area harvested (ha) annual production (kg) and annual production value (RM). The economic value of pollination services was estimated by multiplying production value of each crops with its pollinator dependence ratio. This paper considered four types of crops, namely durian, watermelon, melon and rambutan. Results of analysis on economic value of natural pollinator services based on pollinator dependence ratio was RM 6,588,630.91. These accounted for 56% of the total production values for the region. It demonstrated that the natural pollinators have important impacts and benefits to agricultural sectors through pollination services provided by the nearby forest. With improved pollination services, crop production could be further increased, successful agricultural production, pollination would contribute significantly to world food security.

1. Introduction
Millenium Ecosystem Assessment (2003) and The Economics of Ecosystem Services and Biodiversity (TEEB) has outlined pollination services as one of the regulating service [1, 2]. Globally, one thirds of the total human food supply depend on the pollination. The production of agriculture crops is increasing by 50% through pollination [3]. With improved pollination, crop yields could be further increased by about 25 percent. By ensuring higher yields and successful agricultural production, pollination would contribute significantly to world food security [4].

Pollination services for tropical crops have been compiled by [5] with a list of potential breeding systems and pollinating taxa. Throughout the list, about 70% of tropical crops seem to have at least one variety for which production is improved by animal pollinators. Most common pollinators live naturally in the ecosystem known as wild pollinators. It refers to a species of animals and insects native to particular area, aiding in the pollination of both agricultural and wild plants. The distance between nesting place and food is also important as flight involves a cost for insects. It is also thought that the amount of nectar and pollen and the length of the period when food is available are important in maintaining populations of wild pollinators.

Relationships between natural areas such as forest and pollination are closely linked. Rickett et al. [6] illustrate this with the results of the synthesis of previous related studies that the number of crops visited by wild pollinators is lower for crops areas farther from natural habitat. For tropical crops area
within 5000 metres of their natural habitat receives about 0.5 percent of visits by wild pollinators. The farther the crops from natural habitat, the less potential the pollinators visits.

Two main ways have been used to date to assess the monetary value of pollinators [7]. The first consists in simply assessing the total value of insect-pollinated crops. This approach has been used at a national scale in the USA and as well as in the world scale [8, 9, 10]. However, the production of the most crops only partially reduces in the absence of the pollinators, more refined approach has been developed based on the previous approach. It takes into account the real impact of pollinators on crop production, called dependence ratio. Dependence ratio enables the calculation of the production loss in case of complete disappearance of pollinators, and the economic value of pollination services would assimilate with the loss of crop value.

The dependence of tropical crops on pollen animals has been extensively studied [3, 5, 11, 12]. Klien et al. [3] published the dependency ratio. The value of this ratio determine the average values of the level of dependency of pollinators to the crops. There are several stages of dependency ratio;

i) 95% refers to the average value of reduction of pollen-driven yields is between 100% and 90% in experiments comparing commercial produce with and without animal pollinators. Pollination is reported as "Essential".

ii) 65% refers to reduction of pollen driven revenue is between 40% and less than 90%. Pollination is reported as "Great".

iii) 25% refers to reduction of pollen driven revenue is between 10% and less than 40%. Pollination is reported as "Modest".

iv) 5% refers to reduction of pollen driven revenue is between 0% and 10%. Pollination is reported as "Little".

v) There are also some plants that are not dependent on animal polination and are also known as ‘Parthenocarpic’. However, the list of crops does not cover many crops found in the tropics.

Malaysia is rich with wild pollinator such as bee, stingless bees and bats. Several agricultural crops such as starfruits, guava, citrus, mango, watermelon, durian and coconut among the crops used pollination. Hence, the objective of this study was to quantify the economic value of pollination services by wild pollinators of Gunung Tebu Forest Reserves (FR), Besut, Terengganu. The economic value estimates addressed the contribution of pollination services on the production of crops, thus securing some of the food supply in the region.

2. Materials and Methods

2.1. Study area
The selection of study area is a rich forest reserves of Gunung Tebu, Besut, Terengganu. The reverse is located at the eastern of Malaysia covered with a total of 25,316 ha, about 24km from Jertih town or 118km from the capital city Kuala Terengganu. The reserves also have several recreational attractions such as Lata Belantan Eco-Park and Gunung Tebu peak of 1,039 metres height. Gunung Tebu FR is rich with flora and fauna.

2.2. Data
Data requirement in this study involved the agricultural monthly production reports gathered from the Besut and Setiu District Agricultural Department. The agricultural information for the year of November 2019 to October 2020 collected includes details of;

i) Crops area (ha)

ii) Types of crops planted

iii) Total monthly production (kg)

iv) Production value (RM)
As reference of Rickett et al. (2007), the information collected were directly limited to 5km radius of Gunung Tebu FR. The map shows the area that are within 5km radius from the boundary of Gunung Tebu FR and was used to inform the Field Officer (Figure 1). Data gathered from Besut and Setiu District Agricultural Department as in Table 1.

![Figure 1. The map of 5km radius of Gunung Tebu FR.](image)

| Crops       | Production (kg) | Production value (RM) |
|-------------|-----------------|-----------------------|
| Jackfruit   | 17,300.00       | 17,300.00             |
| Dokong      | 42,577.00       | 43,848.40             |
| Duku        | 90,080.00       | 120,864.00            |
| Durian      | 1,947,873.00    | 9,492,017.90          |
| Mangosteen  | 49,400.00       | 49,400.00             |
| Banana      | 838,187.00      | 1,394,728.00          |
| Rambutan    | 54,527.00       | 83,827.00             |
| Snakefruit  | 22,320.00       | 49,104.00             |
| Watermelon  | 398,590.00      | 360,610.45            |
| Melon       | 72,700.00       | 75,840.00             |
| **Total**   | **3,533,554.00**| **11,687,539.75**     |

2.3. Methodology approach

The analysis of the study uses second approach to calculate the economic value of the pollination services. The total economic value is calculated using Gallei et al. [7];

\[
IPEV = \sum_{i=1}^{I} \sum_{x=1}^{X} (P_{ix} \times Q_{ix} \times D_{i})
\]

Where, \(Q_{ix}\) is the production quantity, \((D_{i})\) is the ratio of crop \(i\) dependence to pollinator and \((P_{ix})\) is the crop price \(i\) per production unit in area \(x\). The values of some tropical crops dependency ratio listed by [3] and also shown by [13] as in Table 2. Table 3 show the calculation of economic value of selected fruits with the dependency ratio.
Table 2. Dependence ratio for local crops.

| Crops     | Pollinator Dependence Ratio |
|-----------|-----------------------------|
| Starfruits| 0.65                        |
| Guava     | 0.65                        |
| Lime      | 0.05                        |
| Mango     | 0.65                        |
| Watermelon| 0.95                        |
| Melon     | 0.95                        |
| Rambutan  | 0.05                        |
| Durian    | 0.65                        |
| Banana    | *parthenocarpic*            |
| Mangosteen| *parthenocarpic*            |
| Duku      | *Unknown*                   |

Table 3. The economic value of pollination services by selected crops (calculation using Gallei et. al, 2009).

| Crops     | Production (kg) | Production value (RM) | Dependency Ratio | Economic Value   |
|-----------|-----------------|-----------------------|------------------|------------------|
| Jackfruit | 17,300.00       | 17,300.00             | -                | -                |
| Dokong    | 42,577.00       | 43,848.40             | -                | -                |
| Duku      | 90,080.00       | 120,864.00            | -                | -                |
| Durian    | 1,947,873.00    | 9,492,017.90          | 0.65             | 6,169,811.64     |
| Mangosteen| 49,400.00       | 49,400.00             | -                | -                |
| Banana    | 838,187.00      | 1,394,728.00          | -                | -                |
| Rambutan  | 54,527.00       | 83,827.00             | 0.05             | 4,191.35         |
| Snakefruit| 22,320.00       | 49,104.00             | -                | -                |
| Watermelon| 398,590.00      | 360,610.45            | 0.95             | 342,579.93       |
| Melon     | 72,700.00       | 75,840.00             | 0.95             | 72,048.00        |
| Total     | 3,533,554.00    | 11,687,539.75         | 6,588,630.91     |

3. Results and Discussion

There were ten types of crops grown around the Gunung Tebu FR, namely durian, banana, rambutan, watermelon, melon, duku, dokong, snakefruit, mangosteen and jackfruits. Durian is the largest producer of crops, followed by bananas and watermelon. The total yield production of crops is estimated to be 3,533,554 kg with production value of RM 11,687,539.80.

The estimation for economic value of pollination services take into account only durian, watermelon, melon and rambutan, since their type of crops required pollination. Most of the pollinators are from natural habitat or wild pollinator. Other crops such as bananas and mangosteen have no dependency towards pollinators (*parthenocarpic*). Meanwhile duku, dokong, jackfruits and snakefruit are said to have dependence on pollinators but the extent of the impacts is not known. Lack of studies have been done for these type of crops towards pollination.

The analyses of four crops with their dependence ratios such as durian (0.65 dependence ratio), watermelon (0.95 dependence ratio), melon (0.95 dependence ratio) and rambutan (0.05 dependence ratio). Based on calculation using Gallei et al. (2009), the economic value of pollination for Gunung Tebu FR and Besut is RM 6,588,630.91. The estimate is equal to 56% of total production value (RM 11,687,539.80) of the area. Hence, the support of pollination services towards the production crops are significant and valuable. It is not only for food resources of the community in the region but also contributed to other area since the production crops were exported.
The actual value of this service will probably be higher than that obtained if taking into account other types of crops. In addition, this value is only the result of HS Gunung Tebu only. Previously published pollination economic pollination studies take into account landscapes compared to individual / specific areas. With improved pollination services, crop yields could be further increased successful agricultural production, pollination would contribute significantly to world food security.

4. Conclusion
The economic value of pollination services from wild pollinators in natural habitat of Gunung Tebu FR in particular and Besut in general is about RM 6,588,630.91. It is equal to 56% of total production value of the area. Hence, the support of pollination services towards the production crops are significant and valuable. It is not only for food resources of the community in the region but also contributed to other area since the production crops were exported.

However, the actual value of pollination services will be higher if pollination services for other agricultural crops are considered in the study. Natural habitats such as forests for pollinators need to be protected to ensure the ecological sustainability of the service as well as to ensure the safety of food resources.

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