Integrating *Styrax-Coffee* Agroforestry System and Apiculture as Alternative Source of Livelihood for Communities in Lake Toba Catchment Area, North Sumatra

Aswandi[1], Cut Rizlani Kholibrina[1] and Apri Heri Iswanto[2]
[1]*Ministry of Environment and Forestry Research and Development Institute of Aek Nauli. Jl. Raya Parapat Km 10,5. Parapat Sumatera Utara*
[2]*Faculty of Forestry, Universitas Sumatera Utara. Jl. Tridharma Ujung No.1 Kampus USU Medan, 20155*

Keywords: Agroforestry, Apiculture, Coffee, Styrax, Lake Toba.

Abstract: The environmental degradation in the Lake Toba Water Catchment is multidimensional, so the recovery effort requires a holistic and integrative approach. Based on its multifunction, agroforestry system has potential for ecological regulation as well as community economic development through bee cultivation. This study aims to illustrate the potential of apiculture practices in agroforestry system in Lake Toba. The research was conducted on coffee-styrax-agroforestry system integrated with Apis and Trigona beekeeping in Aek Nauli, Simalungun, Humbang Hasundutan and Pakpak Bharat, North Sumatra. Results showed that plant diversity in agroforestry system provides feed sources in form of nectar and resin for Apis and Trigona bees. Each Trigona colony produces 30-70 g propolis every two weeks which typical flavor of Styrax incense. Whereas from Apis bee cultivation obtained an average 0.3 liters of honey each stup at two weekly harvest. From this integrated practice, farmers earn income Rp1,2 to 2,4 million per month, the welfare improvement considering bee maintenance is relatively easy and minimal time allocation. The laying of bee colonies around coffee gardens also increase fruit production by flowering intensify. Beekeeping in the agroforestry system opens opportunities for alternative livelihood development, optimization land productivity, as well as increased public nutritional security.

1 INTRODUCTION

The degradation of ecosystem functions of Lake Toba Cathtment Area (LTCA) is multidimensional problem so that the recovery efforts requires a holistic approach, integrated with the active involvement of the local community. Learning from the experiences of previous forest and land rehabilitation programs in this region, identified various causes of failures, including lack of awareness and community participation in forest and land rehabilitation programs, land tenure conflicts and frequency of forest and land fires (ITTO, 2007). The total degraded lands reached 24 thousand hectares, or 18% of total agricultural land and fires often occur at this location (JICA, 2004).

Therefore, improving the land productivity which also develop alternative community sources of income need to be identified. The agricultural cultivation practices combined with a variety of plants that serve to conserve soil and water will improve the efficiency and optimization of land use. These will benefit the improvement of community's source of income. In this case, the model of agroforestry system that integrated with apiculture can be proposed as a scheme needs to be developed.

The utilization of bee keeping in order to increase land productivity and community welfare have been running for a long time. These insects are pollinators agents variety of flowering plants and provider of honey, royal jelly and propolis that contain high nutritional value and health benefits. Bee sting is also used as a medicine to cure various diseases (Halim and Suharno, 2001, Fearnley, 2001). In Indonesia, some of bees species in genus *Apis* and *Trigona* have been cultivated to produce honey and propolis (Widodo, 2011, Tukan, 2008). However, in the LCTA, *Trigona* bee especially has not been widely cultivated. So that, this non-timber forest productt has not been beneficial to the economic development and ecological sustainability of the region.

Aswandi, ., Kholibrina, C. and Iswanto, A.
Integrating Styrax-Coffee Agroforestry System and Apiculture as Alternative Source of Livelihood for Communities in Lake Toba Catchment Area, North Sumatra.
DOI: 10.5220/0008552602520260
In *Proceedings of the International Conference on Natural Resources and Technology (ICONART 2019)*, pages 252-260
ISBN: 978-989-758-404-6

Propolis is a natural nutritional substances and nutraceutical derived from resin substrate that collected by bees from leaf buds nectar and bark of plants which mixed with enzymes and wax from honeycomb (Galvao, 2007). The *Trigona's* propolis contains 35-45% fatty acids, 10% essential oils, minerals, vitamins and other organic substances 5%, 10% pollen and resin 45-55%. Propolis is rich in vitamins (A, B, and C), minerals (Ca, Mg, Na, Fe, Mn, Cu, and Zn), and succinate dehydrogenase enzyme (Hegazi, 1998; Bankova, 2000). The bioactive that contained in propolis include polyphenols (flavonoids, phenolic acids, and esters), terpenoids, steroids, and amino acids (Halim *et al*., 2012; Bankova, 2005; Kumazawa *et al*., 2004). Propolis is used to build and protect the nest, thus it is widely distribute in the entrance and nest edges, eggs and honey wrapping, (Bankova *et al*., 2000).

Since the beginning of the millennium, propolis became known by the market with a very good response. Market demand for propolis continued to increase up to 20% per year (Artdiyasa *et al*., 2010). Considering the high price of propolis, this is an opportunity for community to cultivate *Trigona* bees. Moreover, the bees more adaptableand it is not easy run away. The body size is small and does not bite thus easy to maintain and does not require extensive maintenance area.

If the feed source of *Apis* bees are mostly nectar, the Trigona need resin/saps. High potential of styrax resin in LTCA is the opportunity for the *Trigona* bee development. Approximately 23,592 hectares of styrax forest (*Styrax sumatrana* and *S. benzoin*) found in this region with the scheme that down through the generations since the Middle Ages (North Sumatra Forest Service, 2005; Susilowati *et al*., 2017). Some agrorofrestry practices with styrax, coffee and forest plants such as Callyandra provide both resins and nectar at once. Coffee farming has also been long known, recorded total planted area reached 57,075 hectares in the region (Center of Statitistic North Sumatra, 2015). The feed availability affects the honey and propolis production, and colony growth (Halim and Suharno, 2001; Angraini, 2006). The uncomplicated cultivation techniques, high selling price and demand of propolis are some of the strengths and opportunities for *Trigona* bee development in Lake Toba. A great opportunity for community poverty alleviation in this región.

But the promoting the *styrax-coffee* agroforestry system that integrated apiculture *Trigona* for propolis production and optimizing land use productivity require information related to the potential availability of feed, productivity, nutrients and phytochemicals propolis mainly derived from *styrax* resin, and sustainable plantation schemes that optimize the tree spacing and productivity, result the highest economic income and induce the soil and wáter conservation. As with many non-timber forest products in Indonesia, the financial feasibility of apiculture of Trigona is not yet available. This led to the unclear economic value of this business opportunity for the community.

The objective of this study were to promote *styrax-coffee* agroforestry system and apiculture of *Trigona* bee for white propolis production as alternative source of livelihood for communities in Lake Toba catchment area, North Sumatra. Specifically, the research objectives formulated as follows: (a) obtained the data and information about feed resources availablity for white propolis producer *Trigona* bee on *styrax-coffee* agroforestry system; (b) identified the productivity of propolis *Trigona* that cultivated in styrax-coffee agroforestry system; (c) calcúlated financial feasibility and economic value of apiculture Trigona *bee* that integrated with *styrax-coffee* agroforestry system; and (d) determined the influence of apiculture *Trigona* bee to agricultural productivity and and agroforestry systems and their impact on environmental quality improvement.

2 METHOD

2.1 Research location

The research conducted on various styrax forest/gardens in Pakpak Bharat and/or Humbang Hasundutan District that located around Lake Toba. Historically, these locations are *styrax*-resin-producing regions in North Sumatra. Otherwise, it will be developed a *Trigona* apiculture plot in Forestry Research Institute of Aek Nauli in Parapat, Simalungun Districs. Analysis of phytochemical and nutrient content of propolis conducted at the Laboratory of Biopharmacy Bogor Agriculture University, Bogor

2.2 Method

Activity 1: Identify Sources of Resin.
Based on the information on trees species found in each land cover type, it were identified their potential for nectar and resin production. Information about flowering (phenology) and resin productivity of each tree species were known by literature study and observations in the field. To determine whether a type of trees produce resin or not, it were made a few

notches on a tree. The identification results tabulated as follows.

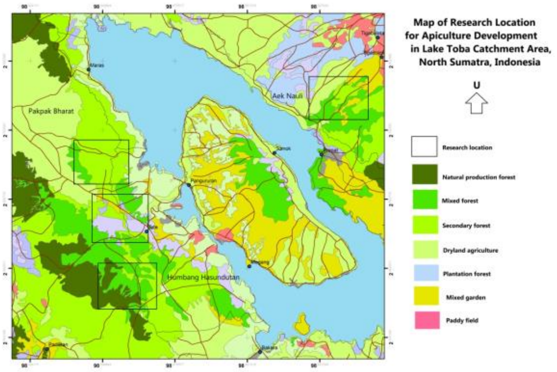

Figure 1: Map of research location on various styrax forest in Lake Toba, North Sumatra.

Activities 2: Measuring the Productivity (Quality and Quantity) of *Trigona* propolis.
The productivity of a *Trigona* colony measured by harvesting the propolis over a period of time. The Propolis harvested and separated from other products such as honey, royal jelly, wax and bee pollen. Yields were weighed, and then extracted to produce propolis liquid. The propolis liquid then weighed to determine the yield of the processing and the quantity and quality of the final product.

Activity 3: Analizing the phytochemical.
Steps of the study consisted of (i) the extraction of propolis, (ii) qualitative analysis of bioactive substances, (iii) and quantitative analysis of bioactive substances. The propolis extraction will be performed by the method of Harborne (1987) and Anggraini (2006). The extraction will be conducted by maceration with 70% alcohol solvent.

Phytochemical analysis will be conducted to determine the presence of active compounds contained in extracts of propolis. The analysis will be carried out by the Harborne method (1987). Identification carried out on flavonoids and phenolic compounds, tannins, essential oils, steroids/triterpenoids, saponins, alkaloids, glycosides, and reducing sugars.

The analysis of bioactive substances will be conducted by gas chromatography-mass spectrometry (GCMS). The analysis is displayed based on the specified temperatures, the temperature in the column will be maintained at 60°C for 2 min and up to 170°C with rate of 3°C/min. Then finally, the temperature is rise to 250°C at a rate of 3°C/min and the temperature will be stable at 250°C for 120 minutes, for each sample. Injection will carried out at a temperature of 220°C. The carrier gas (helium) at a rate of 10 ml/min. The peaks will be recorded to generate a chromatogram.

Activity 4: Economic and Financial Analysis.
Economical analysis method referes to Hesti *et al*. (2013). The study were conducted by interview and focus group discussion. More information were collected to identify of problem, socio-development opportunity, and that risk analysis. The next step were to market price survey and financial analysis by interview. Total respondent for interview was 100 person.

The analysis were done by projecting the position of the commodity in the market systems, the prospects of demand and supply, competition and business feasibility. Apiculture of Trigona bee at styrax-coffe agroforestry system produced raw propolis product and an alternative product processing in the form of a liquid propolis, various agricultural products such as coffee and vegetables, and styrax resin. The study aimed to aspects of demand and supply and the projected value of the Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR). Furthermore Fauzi *et al*, (2007) stated the economic feasibility analysis can be determined by calculating *the return cost ratio* (R/C), *the benefit cost ratio* (B / C) and the *break-even point* (BEP).

All parameters such as a total cost and total revenue calculated within the next 10 years. The 10 years period of the project is defined based on the renewal cycle engine technology. This means that the next ten years the technology has been used machines obsolete and no longer efficient so we need rejuvenation with better technology.

Activity 5: Analysis of Agricultural Productivity/ Agroforestry Improvement and Environmental Sustainability.
Impact of Trigona apiculture on agricultural productivity improvement were determined by calculating the productivity of fruits/seeds of various agricultural commodities/estates such as coffee, citrus, avocados, etc at the certain time before and during the project. The productivity improvements were considered as an increasing in weight, volume and quality of agricultural products that produced around the applied apiculture. The influence of apiculture on the environment can be seen as a difference in the success of flowering and fruit formation of various crops and plants growing in the wild or various other parameters that developed during the study.

3 RESULT AND DISCUSSION

The agroforestry practices have actually existed for a long time in Lake Toba catchment area. In some location, farmers have planted their land with a variety of plants. Various horticultural crops such as chillies, tomatoes, and other seasonal crops are cultivated together with coffee, cloves plantation among shade trees (*Toona sinensis*) and styrax (*Styrax sumatrana*). Short-term income is derived from harvesting vegetables and coffee fruits every two weeks. The resin from *Styrax sumatrana* and *S.benzoin* that managed as shade plants are harvested every six months.

The diversity of species in agroforestry system illustrates farmers' choices in extracting their sources of income by considering the term harvesting, risk and wealth storage (saving) in form of tree stands. The combination of planted species is a manifestation of the farmer's preference for a species and its control over the growing place requirements and economic prospects (Aswandi and Kholibrina, 2017). This arrangement, either vertically or horizontally creates ecological, economic interactions and reflects the regulation of cultivation cycles (Kartasubrata, 2003).

3.1 The Diversity of Feed Plants

The results showed that species diversity in agroforestry system provided the source of feed needed by bees. The Styrax tree provides resin and nectar at the same time, while the massive flowering of Coffee is an abundant source of nectar (Figure 3). The dominant tree species of nectar and resin producers that can be utilized as bee feed are listed in Table 2.

In addition to Coffee (*Coffea arabica*) and Styrax that dominating, there were also others nectar-producing vegetation such as Kaliandra (*Callyandra* spp.), Durian (*Durio zibhetinus*), Mango (*Mangifera* spp.), and Petai (*Parkia speciosa*). The forest tree species that produce resin include Meranti (*Shorea* spp.), Mango, Jackfruit (*Artocarpus heterophyllus*), Breadfruit (*Artocarpus altilis*), and Tusam (*Pinus merkusii*). Forests around the colonies in Pakpak Bharat and Humbang Hasundutan have high species diversity (H$^{'}$> 3), but the forests around the colonies in Aek Nauli, Simalungun have a moderate diversity of species (H$^{'}$ 1-3).

The dominance of Styrax species cause the propolis produced Trigona bees typically flavored styrax because the resin collected comes from the tree. This resin used by Trigona bees to build their hive structures, especially in batumen (protector outside the hives), pillars and honey pots (Figure 3).

Figure 2: Sources of nectar and resins from forest trees and coffee.

Table 2: Styrax forest provide feed sources in the form of nectar and resin.

No	Needs	Functions	Products
1	Pollen	Larvae feeds	Bee bread
2	Nectar	Source of energy	Honey
3	Resin, gum from plant	Batumen (inner side of hive), involucrum (protective coating of brood cluster), cerumen (mixture of propolis and wax to make pillars of hives, honey and pollen pots), brood cells (generally from wax), and gate hive (mixed with sand/soil)	Propolis and geopropolis
4	Honeydews	Source of energy	Honey
5	Oils (collected from flowers cuticula)	Gives a distinctive aroma in the hives	Aromateraphy

If most of *Apis*'s feed is nectar, the source Trigona's bees feed require from resin or sap. The *Trigona* bee collects the leaf resin or stem of the plant which mixed with bee enzymes into propolis. This propolis is used to build and protect the nest so that there are many in the door and hive edges, wrapping eggs, honey and pollen (Bankova *et al*. 2000; Aswandi *et al*., 2017). Styrax and Coffee trees are preferred honeybees because both of these flowers have flowers that are visibly visible or have long filaments and flowering characters are thick and high frequency.

Table 3: Dominant tree species that produce nectar and resin.

No	Tree species	Potency	
		Nectar	Resin
	Aek Nauli, Simalungun		
1	Nangka (*Artocarpus heterophyllus*)		V
2	Haminjon toba (*Styrax sumatrana*)	V	V
3	Haminjon durame (*S. benzoin*)	V	V
4	Tusam (*Pinus merkusii*)		V
5	Damar (Agathis dammara)		V
6	Meranti (*Shorea* spp.)	V	V
7	Kaliandra (*Callyandra* spp.)	V	
8	Rasamala (*Altingia excelsa*)	V	V
	Pakpak Bharat		
1	Haminjon toba (*Styrax sumatrana*)	V	V
2	Haminjon durame (*S. benzoin*)	V	V
3	Tusam (*Pinus merkusii*)		V
4	Mahang (*Macaranga* spp.)	V	V
5	Jabon (*Anthocephalus cadamba*)	V	V
6	Mangga (*Mangifera* spp.)	V	V
7	Melinjo (*Gnetum gnemon*)	V	
8	Kaliandra (*Callyandra* spp.)	V	
9	Petai (*Parkia speciosa*)	V	
10	Meranti (*Shorea* spp.)	V	V
11	Durian (*Durio zibhetinus*)	V	
12	Sukun (*Artocarpus altilis*)		V
	Humbang Hasundutan		
1	Haminjon toba (*Styrax sumatrana*	V	V
2	Simartolu (*Schimawallichii*)	V	V
3	Petai (*Parkia speciosa*)	V	
4	Kopi (*Coffeea arabica*)	V	
5	Kaliandra (*Calliandra* spp.)	V	
6	Tusam (*Pinus merkusii*)		V
7	Jabon (*Anthocephalus cadamba*)	V	V
8	Rasamala (*Altingia excelsa*)	V	V
9	Mahang (*Macaranga* spp.)	V	V
10	Makadame (*Macadamia hildebrandii*)	V	
11	Durian (*Durio zibhetinus*)	V	

3.2 Flowering of *Styrax*

The flowering observation were conducted on ten sample trees in Aek Nauli forest from Mei to November 2017. Kemenyan Toba flowers have a compound structure. It are arranged in a bunch or panicle (inflorescence) with 5 to 12 flowers in a bunch (Figure 2). The panicle of flower is at the tip of the branch with an upright position. The development of flowers from buds form to matured fruits is not the same period in one bunch (Kholibrina, 2017). There are a tendency that flowers in the top position is bloom

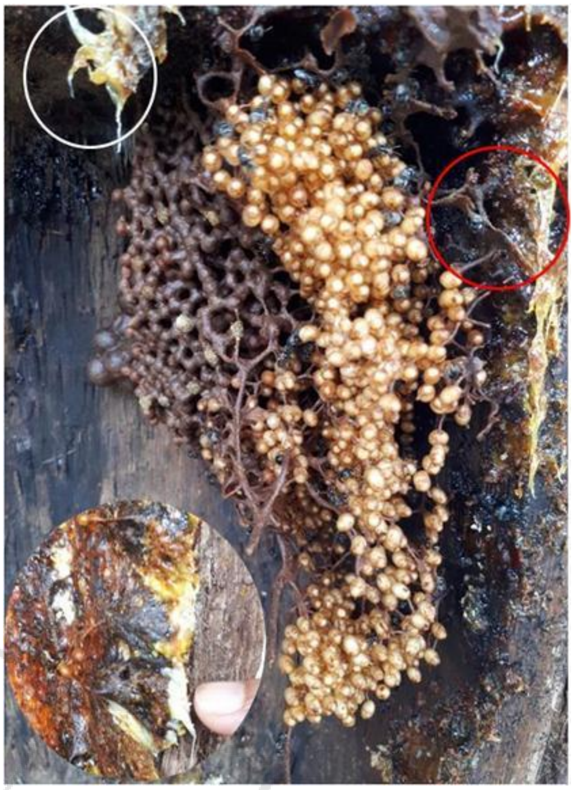

Figure 3: *Trigona laeviceps*'s hive structures constructed from resin.

first and then continued by the flowers at the bottom. The flower character and its structure are closely related to the type of pollination either by animals or wind (Sedgley and Griffin, 1989).

According to flower types, shapes and colours, the pollination were identified occurs with insect vectors, naturally. Bees and butterflies were observed flying around the flowers at 08.00-11.15 WIB (Kholibrina, 2017). Trigona's daily fly activity at the study site also similar to the time range:

a. 07.00 - 10.00 WIB: fly out the hive, looking for feed (nectar and resin)
b. 10.00 - 14.00 WIB: around the hive
c. 14.00 - 16.00 hrs: fly out the hive looking for feed (nectar and resin)

The flowers have white or cream color, irregular or tubular shapes, consisting of several parts, there are places of landing and flowers frequented by bees and moths (Palupi, 2001). The genital expression is hermaphrodite, where ♂ and ♀ consisted in a same flower, with anther and stigma close together, allowing for self-pollination. There were identified nine anthers that surrounded, with sticky pollen. There were indicated from the observed anther have been opening during investigation. Another tree species with sticky pollen is Teak (*Tectona grandis*) with medium tricolpatc form (Owens *et al.*, 1996). An anther and stigma position adjacent to each other is shown in Figure 5. The nature and shape of pollen will affects the controlled pollination patterns.

The anther and stigma positions are close together, but the compatibility is unknown. This condition raises the possibility of self pollination (autogamy) and cross (allogamy). The proportion of self and cross-pollination in a population are influenced by self-sterility, flowering behavior and the presence of pollinating vectors (Kittelson and Maron, 2000, Satifah and Darjanto, 1984). Generally, flowers have a natural mechanism to reduce their self-pollination both temporal and spatially. In this case, temporarily, the ripening of male and female flowers occurs at different times, whereas male flowers are spatially separated from female.

Petal is white and it is a part of flower to attract insects to pollinate. White pistil surrounded by orange stamens, light green sepals attached to bottom of the ovary. Diameter of flowers reaches 18 mm at the bud form, when blooming it reach 91 mm (Kholibrina, 2017). The panicle length is 65.4 to 75.0 mm, and the length of the stylus is 15 mm. The stamen length is 11 mm and it has 9 anthers. The stylus is longer than stamen. This is a defense mechanism to minimize the self-pollination. The anther is slightly hairy with a bright orange color when ripe and the stigma (pistil) is slightly slimy with a bright greenish white color when receptive condition.

The flowering development starts from the emergence of generative shoots that come out from the leaves armpits in the form of small bends, then developed into a flower bud (designated panicles). Shoots of panicles will develop into a clearer flower arrangement with petal still closed. Flowers on the buds develop to a complete flower structure with petal still in bud form. Further, individual flowers bloom with light green sepal color and white pistil parts (receptive flower conditions). If pollination occurs, the flowers will abort the petals and ovule starts to swell (Kholibrina, 2017).

The designated flowers or generative shoots begin to appear at the end of June to July, then flower will appear and elongate at the end of August. In August to September the flower buds on the panicle grow and emerge a white petal. Generally, the flower blooms in August to September. In late September to early October, the flowers fallen, and fertilization process has begun.

The flowering development occurs for 30 to 152 days, begin from the growing of generative buds, the flower's shoots and bursts is developed, and young fruits ismatured. The developmental period of flowering of *S. sumatrana* is shown in Table 1. It is illustrates that the flowering cycle of this species incidence relatively longer than *S. benzoin*. The latter takes between 35 and 62 days (Syamsuwida *et al.*, 2014).

The flowers appear after the budding period. The number of *Styrax* flowers in one panicle varies in one tree as well as compared to other trees and the wind direction. Variations in the number of flowers often reported in tree plantations such as variations of flower production among clones, canopy and season in the seed orchard of *Pinus sylvetris* (Burczyk and Lewandowski, 1998).

Environmental factors such as the adequacy of sunlight and soil nutrients affect the flowering. The sunlight reception is related to photosynthesis rate as a energy source for flowering process. The observations were showed that branching in the East has a higher proportion of flowers than in the West direction (Kholibrina, 2017). This is related to the intensity of sunlight received. Conversely, the less intensity of sunlight affects the flowering inhibition in reverse direction. While the availability of soil nutrients associated with energy supply and building materials for formation and development of flowers. The effects of competition among individual trees also determine the flowering (Burczyk and Lewandowski, 1998).

3.3 Productivity and Propolis Content

The harvesting technique and post-harvest processing of *Trigona* honey is similar to *Apis cerana* bee, using a knife to harvest the honeycomb, but requires a kind of pipette or pressurized pipe to suck honey from its pot. Then, honey is collected in a bottle. While the harvesting of propolis were conducted by scraping propolis around the wooden door, or scaping the hives that honey and pollen have been harvested.

Trigona and Apis bee cultivation in agroforestry systems prove the high potential of propolis and honey produced. Each Trigona colony produces 30-70 g of propolis every two weeks. Whereas from *Apis* obtained an average of 0.3 liters of honey each stup at biweekly harvest. If each farmer keeps each ten *Apis* and *Trigona* bee stups, from the cultivation of these bees and the Coffee harvest every two weeks, farmer earns Rp1.2 to 2.4 million per month. The addition of family income is quite good considering how the maintenance of *Apis* and *Trigona* bee is relatively easy and allocated time is minimal.

According to Saepudin (2011), the effort to integrate Coffee plantation with honey bee (*Apis* *cerana*) in Kepahiang, Bengkulu can accommodate stup as many as 66 - 250 stups per hectare. However, the capacity of Coffee plantation to accommodate bee colony should be supported by other species such as Kaliandra to maintain the continuity of bee feed when Coffee is not flowering.

Propolis is a natural nutrient collected bees from leaf shoots resin and bark of plants mixed with bee enzyme (Galvao, 2007; Lofty, 2006). Based on testing of the active phytochemical content performed, propolis of the styrax stand contains polyphenols (flavonoids, phenolic acids), terpenoids, steroids.

Propolis is used by bees to build and protect their hive, so there are many in the door and the edge of the nest, wrapping eggs, honey and pollen (Bankova *et al*., 2000). Propolis Trigona contains 35-45% fatty acids, 10% essential oils, minerals, vitamins and other organic substances 5%, 10% pollen and 45-55% resins. Propolis is rich in vitamins (A, B, and C), minerals (Ca, Mg, Na, Fe, Mn, Cu, and Zn), and enzyme succinic dehydrogenase (Hegazi, 1998; Bankova, 2000).

3.4 Economic Value and Trading System

Most of the Apis and Trigona honey produced by farmers at the research sites are marketed through collecting trader before they delivere to end consumers. However, honey marketing directly from farmers to consumers were also found.. But, there are no raw propolis produced that marketed directly to consumers. Beside processed in the domestic industry in small quantity, the raw materials are exported and processed abroad before being re-imported and marketed to consumers.

Increased attention to organic medicines have boosted market demand for propolis and honey increase by 20% annually. However, most of these commodities needs are still met from imports (Aswandi and Kholibrina, 2016). Some distribution companies began to engage in propolis marketing by importing propolis extracts for processing in liquid form domestically (Harsanto and Maharani, 2011). This import is applied because domestic commercial propolis extract product not yet available. This fact represents an opportunity for the provision of liquid propolis by utilizing local raw propolis that have not been worked out (Aswandi and Kholibrina, 2016).

This is actually an opportunity for local community to cultivate bees Trigona propolis producer, especially according to extract propolis price is very expensive on market. The potential of Trigona bees to produce propolis is much higher than other bees. These bees also have a small body size and stingless, easy to adapt and easily maintained. These bees are often hived in tree cavities, bamboo holes and cracks in house walls (Dollin et al. 1997; Michener 2007).

3.5 The Influence of Trigona Bee Cultivation on Productivity

Trigona's characteristic and short-flight range, making it focus on trees around the hive, making pollination more intensive than *Apis* bees with further flying range (Michener, 2007; Aswandi and Kholibrina, 2016). Some studies suggest an increase in cultivated crop production if a number of Trigona bee colonies are placed around the plant site. The laying of the bee colony in the coffee plantation also shows an increase in the number of the fruits (Aswandi and Kholibrina, 2016).

In another study, number of harvested avocado fruit production were increased, from 100 fruits per harvest becomes about 200 fruits per harvest after the presence of Trigona bee colony as a pollinator around the avocado tree. It also can be seen clearly from the number of flowers and fruit from cultivated plants that are always abundant throughout the year, such as coconut, coffee, melinjo, and Kaliandra so it can be enjoyed by farmers and also the owners of the garden (Baconawa, 2002).

The abundant of potential feed resources, uncomplicated cultivation techniques, high selling prices and demand for propolis products are some of the strengths and opportunities for the development of Trigona bee cultivation in Lake Toba (Aswandi and Kholibrina, 2016). The existence of interdependence between bees and vegetated environment will encourage efforts to maintain vegetation cover in Lake Toba catchment area. Through the bee cultivation practices were expected to encourage the community to maintain their environment by not doing the logging, destruction or burning of land as it often happens during decades in this region.

Agroforestry systems that combine seasonal crops with plantation crops, fruit trees and forestry provide a source of nectar and resin. The development of honey bee cultivation and propolis producers in agroforestry systems provides opportunities for alternative sources of livelihoods and increases the crop productivity. Honey and propolis produced are also expected to increase the nutritional and public health.

4 CONCLUSIONS

The agroforestry practices have actually existed for a long time in Lake Toba DTA. Some farmers in this area have planted their land with a variety of plants. The diversity of species in agroforestry system illustrates farmers' choices in extracting their sources of income by considering the term harvesting, risk and saving in tree stand form.

Trigona bee cultivation in the agroforestry system proves the high potential of propolis and honey bees produced. Propolis produced a typical aroma of styrax and contains phytochemical compounds polyphenols (flavonoids, phenolic acids), terpenoids and steroids.

The abundant feed resources, uncomplicated cultivation techniques, high selling prices and demand for propolis products are some of strengths and opportunities for *Trigona* cultivation development in Lake Toba. The development of honey bee cultivation and propolis producers in agroforestry systems provides opportunities for alternative sources of livelihoods and increases in crop productivity.

REFERENCES

Angraini, A. D. 2006. Potential of Bee Propolis Trigona spp. as an Antibacterial Material. Thesis. Bogor Agricultural Institute. Not published.

Artdiyasa, N., Chaidir, A., Wirawati E. K., Susanti T. 2010. *Trigona: Bee producing propolis.* Trubus Online. http://www.trubus-online.co.id. [10 Oktober 2010].

Aswandi, Kholibrina C. R. 2016. Potential Integrated Agroforestry-Apiculture Development for Watershed Ecosystem Restoration and Enhancement of Lake Toba Public Welfare. In *Proceedings of the National Seminar on Information Technology and Innovation III, Samosir 11-12 November 2016*. Medan State University.

Aswandi, Kholibrina C. R. 2017. *Lake Toba Ecosystem Recovery*. Medan: Bina Media Perintis.

Baconawa A. D. 2002. The economics of bee pollination in the Philippines. The Mayamang Masa Multi-Purpose Development Cooperative (MMMPDC) Bee Project. http://www.beekeeping.org/articles/us/pollination_philippines.htm. [27 Agustus 2016].

Bankova V. S., de Castro S. L., Marucci, M. C. 2000. Propolis: Recent advances in chemistry and plant origin. *Apidologie* 31, 3-15.

Bankova, V. S. 2005. Recent Trends and Important Development in Propolis Research. *Evidence-based Complementary and Alternative Med*, 2, 29-32.

Burczyk, J., Lewandowski, C. 1998. Resin production of scots pine trees maybe associated with multilocus allozyme variation. *Arboretum kdrnickie*, 43,79-83.

Fearnley, J. 2001. Bee Propolis Natural Healing from The Hive. Souvenir Press Ltr., London.

Galvao, J. 2007. Biological therapy using propolis as nutritional supelemen in cancer treatment. *Int J Cancer Res*, 3(1), 43-53.

Halim, E., Hardinsyah, Sutandyo, N., Sulaeman A., Artika, M., Harahap, Y. 2012. Bioactive and Nutritional Studies of Propolis in Indonesia and Brazil. *Nutrition and Food Journal*, 7(1), 1-6.

Halim, M. N. A., Suharno, 2001. *The Royal Jelly grafting technique*. Kanisius, Yogyakarta.

Harborne J. B. 1987. *Phytochemical Method*. 2nd edition. (Padmawinata K, penerjemah). ITB, Bandung.

Harsanto, B., Maharani. 2011. Business Aspects of Indonesian Local Liquid Propolis Development. In *Proceedings of the National Research Seminar and PKM of Science, Technology and Health*, 2 (1), 195-200. http://prosiding.lppm.unisba.ac.id/index.php/Sains/article/download/51/pdf.

Hegazi A. G. 1998. Propolis an overview. *J Bee Informed*, 5, 22-28.

JICA, 2004. The study on integrated regional development and environmental conservation management in the area of Lake Toba with participatory approach. PT. Indokoei International.

Kartasubrata, J. 2003. Social Forestry dan Agroforestry di Asia. Bogor: Fakultas Kehutanan IPB.

Kholibrina C. R. 2017. Flowering of Kemenyan Toba Tree (*Styrax sumatrana* J.J.Sm.) at Aek Nauli Arboretum, North Sumatra. In *Proceedings of Aek Nauli Research Research Institute for Environmental Development and Forestry Research Center. Forest Products Research Center. Research and Development Agency and Innovation*

Kittelson, P. M., Maron, J. L. 2000. Outcrossing rate and inbreeding depression in the perennial yellow bush lupine, Lupinus arboreus (Fabaceae). *American Journal of Botany*, 87, 652-660.

Kumazawa, S., Hamasaka, T., Nakayama, T. 2004. Antioxidant activity of propolis of various geographic origin. *Food Chemistry*, 84, 329-339

Lofty, M. 2006. Biological activity of bee propolis in health and disease. *Asia Pac J Cancer Prev*, 7, 22-31.

Michener, C. D. 2007. The bees of the world 2nd ed. Baltimore: Johns Hopkins University Press.

Owens, J. N., Sornsathapornkul, P., Tangmitchareon, S. 1996. *Studying Flowering and Seed Ontogeny inTropical Forest Trees*. ASEAN-Canada Forest tree Seed Centre. Muak Lek, Saraburi. Thailand.

Palupi, E. R. 2001. *Pollination, fertilization and seed development*. The 3rd Training on Seed Biology. IFSP-BTP. Forestry Research and Development Agency. Ministry of Forestry and Plantation. Bogor.

Saepudin, R. 2011. Productivity of honey bees (*Apis cerana*) on the application of a system of integration with coffee gardens [Thesis]. Bogor: Post Graduate School of the Bogor Agricultural Institute.

Satifah, Darjanto. 1984. Basic Knowledge of Flower Biology and Artificial Cross Pollination Techniques.Gramedia, Jakarta.

Sedgley, M., Griffin, A. R, 1989. *Sexual Reproduction of Tree Crops*. Academic Press.

Susilowati, A., Hendalastuti, H., Kholibrina C. R., Ramadhani, R. 2017. Weak delineation of *Styrax* species growing in North Sumatra, Indonesia by *matK* + *rbcL* gene. *Biodiversity,* 18(3), 2085-4722. DOI: 10.13057/biodiv/d180353.

Syamsuwida, D., Aminah, A., Nurochman, N., Sumarni E. B., Ginting, J. 2014. Flowering and Fruiting Development Cycle and Fruit Set of Kemenyan (*Styrax benzoin*) at Aek Nauli. *Journal of Plantation Forest Research*, 11(2), 89-98.

Tukan, G. D. 2008. The Effect of *Trigona* spp. propolis from Pandeglang to several isolates of cow intestinal bacteria and tracing the active component [Thesis]. Bogor: Postgraduate School, Bogor Agricultural Institute.