

Indigenous and Local Knowledge about Pollination and Pollinators associated with Food Production



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1. Indonesian forest communities: Indigenous and local knowledge of pollination and pollinators associated with food production

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1.1. Background – one honeybee species, four regions

The Asian giant bee, *Apis dorsata*, is one of the largest species of the genus *Apis*. The colonies build nests in the open air, hanging underneath the branches of large trees, on rock cliffs, or sometimes buildings. Their nest is formed by a single vertical comb which can reach one to two meters long and a meter and half in height. Colonies are gregarious and one can find more than a hundred nests on the same site. The colony contains one single queen and several males during the breeding season. A single comb can contain up to 10,000 workers grouped in several layers on its surface. The species is known to collectors for its aggressiveness and the high mobility of its swarms. Indeed, colonies often migrate, either according to the season, blooms or disruptions that they may face. Bees then abandon their nest and can fly for several kilometres in search of new food sources. It was observed that after several months or even a year or two, bee colonies return to settle on the same branches of the same tree.

In Indonesia, as elsewhere in South and Southeast Asia, the vast majority of combs are collected on branches by climbers specialized in their collection. These honey gatherers or hunters are more or less regular in their activities according to the number and frequency of seasons, site accessibility or their motives for collecting combs. All take significant risks by going to harvest honey in nests that are often difficult to access. Collectors are not roped and accidents are not uncommon. In Indonesia, some small social groups, most of them composed of honey tree collectors, have developed a form of management of *Apis dorsata* colonies. This is the case in particular on the islands of Bangka-Belitung and in the Sentarum lake region in West Kalimantan. This technique known as the “rafter” technique consists of setting up on the ground or at ground level a slightly inclined support, a hardwood plank (called *tikung*) in Sentarum lake or a tree trunk in Belitung (called *sunggau*), under which the bees establish their colony by building their single-comb nest. The installation and location facilitate the arrival of the bees at the time of their migrations and allow for regular and secure harvests. The technique is directly inspired by the habit of bees to

nest beneath branches and recreates the ecological niche sought by colonies. Combined with detailed knowledge of the species' life cycle and biology (see also Roué et al. 2015) and strong social regulations, the technique allows for a simple but effective beekeeping.

The information compiled here comes from ongoing research work (Nicolas Césard in Bangka-Belitung and Sentarum Lake; Valentinus Heri in Sentarum Lake). They reflect the views of the respondents but rest solely with their authors. Following the meeting in Panama, we organized a discussion seminar on the island of Belitung, Indonesia. We asked eight honey collectors/harvesters from four regions in Indonesia (Banten, Belitung, Riau, Sentarum Lake) to share their knowledge and also integrated them into the text. The four sites introduced are the following:

- ▶ **Banten.** Created in 2009, the Association of Ujung Kulon forest honey harvesters (*Kelompok Tani Madu Hutan Ujung Kulon* or KTMHUK) includes collectors from four villages along the Ujung Kulon National Park (UKNP). The park is located at the western end of the island of Java in the Banten province (district of Pandeglang). Its area is 1,206km² (of which 443km² is offshore). Collectors are Sundanese Banten (*Sunda Banten*).
- ▶ **Belitung.** Belitung is an island in the Java Sea southeast of the islands of Sumatra and Bangka. With a land area of 4800km² it was initially covered by lowland tropical forest but since the development of the palm oil industry in 1992 over half of its surface is covered with plantations. The majority of the inhabitants are Belitung Malays (*Melayu Belitung*) living from fishing and agriculture. Honey harvesting is practiced in many villages.
- ▶ **Riau.** The Tesso Nilo National Park (TNNP) is located in Riau province in the island of Sumatra. Designated as a protected area by the Indonesian government in 2004, its original area of 385 km² was extended to 850 km² in 2009. The park suffers numerous encroachments from illegal loggers and settlers who clear the park for crops and palm oil plantations, as well as village sites. Since 2009, a local association of forest honey collectors (*Asosiasi Petani Madu Hutan Tesso Nilo* or APMTN) manages harvesting activities (with the help of the WWF). More than 280 trees hosting bee swarms have been listed. Collectors are Riau Malays (*Melayu Riau*).
- ▶ **Sentarum Lake.** Located in West Kalimantan (Borneo), the Danau Sentarum National Park (DSNP) covers an area of approximately 1320km² hectares of lakes, rainforests and periodically flooded forests. The park has 39 permanent or seasonal villages. The majority of the population is Kalimantan Malays (*Melayu Kapuas Hulu*) whose main activity is fishing. Almost 10% of the population is composed of Dayak groups, mainly Iban (*Dayak Iban*) whose activity is mainly agriculture, then hunting and gathering of forest products and fishing. Since 1996, most of the region's honey harvesters have joined together in an association (*Asosiasi Periau Danau Sentarum* or APDS).

1.2. Value of insect pollinators and of their food source

In Indonesia, knowledge related to the foraging activities of bees and to their interactions with flowers (more than to the process of pollination itself) is fundamental to the organization of forest honey harvesting activities, i.e. honey hunting and beekeeping. Forest collectors have comprehensive knowledge of various bee species, especially the one they observe in their regular practices and use for wax or honey. They give names to bees, to their offspring and to their products, and distinguish honeybees from other bees, including more solitary species. The Asian giant honeybee is the most harvested bee species and the most well-known, even if honey from stingless bees and from *Apis cerana* and from *Apis florea* can also be collected in several regions of the archipelago (mainly from the wild). Honey collectors regularly observe the evolution of their nest, the honeybee activities on the comb, their trips and foraging behaviour on flowers. As with bees and in relation to them, collectors are also attentive to flowers and to their development. In



the four regions, people have developed a good understanding of blooms and flowers producing nectar and pollen. This knowledge, however, may be different from one social group to the other and from one individual to another. Most of the time, knowledge on flowers and flowering periods allows harvesters to prepare for the coming of the honeybee swarms and once the bees have settled on a site to predict at what the time to harvest honey. Honey collectors associate the main migrations of the giant Asian honeybee colonies to their nesting sites to seasonal massive blooms, an ecological phenomenon (known in the scientific literature as General Flowering events) in which most trees of most tree species flower simultaneously at more or less random times of year.

Flowerings constitute the main indicator to harvest honey and although harvesters know approximately from one year to another which trees will bloom and when (by experience but also by watching the buds before they start to bloom), they can hardly predict the abundance of flowers and the duration of the blooming. Plant species harvested by bees change from one region to another and often vary within the same geographical area, in particular depending on the abundance of tree species. Some flowering periods and honey seasons last for months since various tree species bloom one after the other. In other areas, most trees bloom massively during a short period of time and the honey-harvesting period is limited to a few months. In Riau (Tesso Nilo National Park), collectors report that bees find flowers to forage all year around and that a careful harvester (one, as we will see, who do not use smoke) can collect honey almost every month. They observe that *rengas* (*Gluta velutina*), *kuras* (*Ostodes paniculata*) and *laban* (*Vitex pinnata*) trees are among the most productive and some trees bloom twice in a year. Flowers are not the only source of nectar, since bees also collect honeydew from acacia leaves (*Acacia mangium*) in the early morning. In Banten, Ujung Kulon NP, the collection of honey is more seasonal. It usually starts in May with the *salam* (*Syzygium polyanthum*) trees, and lasts a few months. The collectors know that trees bloom during the dry season and that depending on its length and of sites (forest or coastal areas) flowers will change every month until the start of the next rainy season.

In the four regions, bee swarms are known to arrive with blooms and follow their seasonality. Most collectors distinguish tree species producing mainly pollen from those producing nectar (and not certain flowers of the same tree species). They believe that bee swarms come for the nectar source but once they have arrived, they collect pollen first from various sources while waiting for the nectar flowers to open. In Borneo (Danau Sentarum NP), rainfalls almost continuously fill the region's lakes, with the exception of a short period between June and August during which they dry out, some completely. This seasonality has great consequences for the vegetation and for the fauna. The end of the dry season is followed from December to February by a rise in water level, which leads to bud induction and to massive and successive blooms. This period is vital to the honeybees and sees the arrival of numerous colonies. (Collectors also observe bird migrations. They know that the *cincin apai* bird comes to nest when the lakes dry out and that the newborns are ready to fly once the water rises). In the flooded forests then, many species of tree are flowering of which around 20 species are important for honey production such as the *masung* (*Syzygium claviflora*) and the *tahun* (*Carallia bracteata*) trees (see Mulder et al. 2000). Further west, on the island of Belitung, the type of honey harvested also change depending on areas and periods of the year. Collectors report that in the coastal forests, dominated by small-sized trees, the *gelam* tree (*Melaleuca leucadendron*) is prized by honeybees for its nectar and the *jemang* (*Rhodomnia cinera*) and the *betor* (*Calophyllum pulcherrimum*) trees for their pollen. In the island's interior, the bitter honey of the pelawan trees (*Tristania obovata* and *T. whiteana*) is the most sought after.

The regularity of the main flowerings allows harvesters to anticipate the arrival of the swarms and to prepare themselves to harvest the nests. In the lake region of Sentarum, colonies arrive from the surrounding hills in December and settle first on the tall trees (*lalau* or *tapang*) on which their combs are collected. Then, several tree species in the flooded forests come into bloom and the swarms move on low vegetation where they find the honey planks (*tikung*) already set up. In the village of Leboyan, in the southern part, the bees come for the *tahun* flowers, then for those of *putat* (*Barringtonia acutangula*), before moving to *kawi* and *tembesu* flowers. To prepare for the bees in Tesso Nilo NP, like in Sentarum Lake, the base of the large trees where the colonies nest (the tree is called *sialang*) are

cleared of small and fast growing vegetation and metal sheets are installed around the tree trunk to prevent bears from climbing. On Belitung Island, the colonies migrate regularly, especially when the main flowerings approach. According to the harvesters, some swarms come from the island's interior while others migrate from more distant regions like from the coasts of Sumatra and Borneo (those come specially for the *gelam* flowerings and build bigger combs than local swarms). As in Sentarum Lake, the harvesters prepare themselves for the bee arrival: between two blooms, they change the most damaged honey trunks (*sunggau*), build new structures, and clean and prepare the sites by cutting the unwanted trees and branches. When flowers bud, they know that the swarms will look for the best locations. They have observed that the swarm stays on a tree first, from which it sends some scout bees to check if the branch or the structure is suitable for the colony to nest.

Whereas the placing of honey planks and tree trunks relies predominantly on ecological observations which we will not explain in detail here, the harvesting of honey requires the harvesters to understand the development of the comb on the support, and also the bee lifecycle and their interactions with flowers. On nesting sites, and when the distance allows it, harvesters regularly observe the bees' comings and goings and their activities on the comb. Belitung harvesters then notice that the bees stay on their nest during rainy days (and consume their pollen and honey stocks) and that they visit flowers during moonlit nights. Most of the observations are done on the honey planks or trunks taking place around the comb or on its surface, often at ground level, and several indications enable harvesters to know when the honey harvesting can take place. Honey collectors combine several signs that they have observed during previous harvestings. Those include pre-harvesting indications on the comb occupied by bees, and also post-harvesting indications once the colony has been smoked and the wax cells and the brood are visible.

In Belitung, like in the Sentarum lake region, harvesters are paying attention first to blossoms. They know that the swarms arrive when the buds open (*nungkul* in Belitung language), but also that they will leave again soon after the end of the flowering periods. The harvesters rely on the general observation that once flowers are faded (they said once "dry up") bees do not seek nectar anymore and the cells on the comb containing honey are sealed. More precise observations depend on flower species. In the flooded forests of Sentarum Lake, the harvesters are attentive to wilting and to colour change (the *tahun* flowers are known to change gradually from white to red), as well as to the falling of petals in the river (when the *putat* petals fall comes the time to harvest). Likewise, when harvest approaches, direct observation of the comb gives several indications which confirm its development. By regularly viewing the occupied comb in profile Belitung harvesters can deduct the replacement of the pollen by honey on the superior part of the comb, bees expanding the alveoli as they fill them up with honey. At distance again, they observe the bee activity on and around the comb: when worker bees do not move on the pollen cells and that they fly less back and forth, they know that bees do not produce honey anymore and that their stocks of pollen are getting depleted. Bees do not leave their nest in mass to defecate and change position on the surface layer of the comb as they use to do everyday (this periodic flight is called *ngerunsai*).

Some flowerings are short and some harvesters have noticed that those blooms are insufficient for the colony to fully develop. The colony produces new bees, but is living on limited stocks of pollen and honey. Also, the comb is not overcrowded with old and new bees. In the absence of new flowers, harvesters know that bees will swarm to better locations (known in the literature as non-reproductive swarming), according to harvesters some of which may be in neighbouring areas, others may be in far more distant regions. Other flowerings can last longer and the colony has plenty of time to reach maturity ("to grow old" as collectors say). This is the case with the geographically localized *gelam* trees in the south of Belitung, whose flowering period can last two months, or even three in certain areas. Colonies are taking advantage of the abundance of the floral resources available to produce queen cells (a frequent observation in Belitung), and eventually mate and start up new colonies (known as reproductive swarming). Most harvesters did not actually see the scission of the colony, but consider the accumulation of bees on the lowest part of the comb as their last chance to collect honey. Then, if the harvesters can hardly predict the abundance of blooms and their duration (they say because of changing weather conditions), they know how the bees behave during flowerings, the fact in



particular that the bees swarm quickly at the end of short flowering, but also that they can stay on the comb and rebuild their stocks of pollen and honey if more flowers appear in the next days.

In Belitung, the most experienced individuals harvest honey at least one week after the arrival of the swarm (for those who want to harvest quickly), and always a bit before the last flowers of a bloom died. They also have observed that when a flowering lasts (the ongoing one or another one), a second harvest can take place two weeks, and sometimes three weeks, after the bees are settled. The harvest being based on the observation that bees come and go with flowers, the harvesters hurry to intervene since they know that the colony in absence of new flowers is going to deplete its pollen to feed its larvae and to consume its honey to prepare for swarming. They know from experience that without a new flowering the bees will stay only a few days on the comb before leaving. The most conservative action (to obtain a maximum of honey) is then to anticipate the colony departure by proceeding quickly to the harvest. To do so, harvesters smoke the bees (photo below), then take the honey at the extremity of the comb and cut the brood (which is often eaten raw or cooked back home). The situation changes if other flowerings are coming: harvesters know that if they take the honey from the comb, but leave behind the pollen and the brood, they can proceed to a second harvest, and even a third, since the “bees” (note: here the queen) lay eggs again and wait until most larvae change into adult insects to swarm.



Smoking the comb in rafter beekeeping, Belitung, Indonesia, December 2011

Collectors follow flowerings and most of them have a good knowledge of the bee development on the comb and inside the cells. However sometimes it seems easier to count the days once the blooms have started and the bees have settled. In Ujung Kulon NP, the honey season lasts a few months and nests are harvested once they are encounter during collecting expeditions in the forest. Collectors acknowledge that they cannot wait too long for the bees to develop. Once a seasonal blooming starts, they wait two weeks before looking for honey to harvest (even if they know that the larvae still need more days to grow). In Tesso Nilo NP, harvesters have made the choice of taking advantage of the abundance of flowers all year around. They made several samples to determine when to collect and have collectively decided not to harvest before 24 days, 33 days being the ideal time for honey quality (they have noticed that water content is not too high). Harvesters now leave the pollen on the comb so the bees feed their larvae, continue to develop and produce more honey

every month. In general, harvesting honey too fast appears counter-productive, especially when bees are still looking for flowers. According to one collector in Belitung, to avoid honey and pollen being mixed up during extraction and decreasing honey quality, it is always better not to harvest honey when bees are still foraging for pollen. This is unfortunately the case when bees collect flowers producing nectar bloom before those producing pollen.

1.3. Non-economic value of insect pollinators and of their products

In the four regions, most collectors harvest honey regularly for sale. Collectors have various methods to reach branches or access combs. In Sentarum Lake, swarms nest on tall trees (honey or bee trees) called *lalau* by the Malay collectors (trees such as *rengas* (*Gluta reinghas*); *tempurau* (*Dipterocarpus gracilis*), and *ran* (*Dipterocarpus tempehes*)) and known as *tapang* by their Iban neighbors (trees mainly from the genus *Koompassia*, *K. malaccensis* or *K. excelsa*, often stand up alone on the hills surrounding the lakes). Harvests take place during moonless nights. One or two days before, collectors meet to build up the ladder that allows them to climb along the trunk. In Sentarum Lake, collectors use two techniques. The first (*jantak*) is to plant every two or three meters bamboo stakes in the trunk and to tie them up with rattan to the ladder. The second one (*pakau*) consists of banding with rattan the ladder around the *sialang* trunk and to fasten wood steps to it, a last method favoured by those who want to preserve the tree. In Tesso Nilo NP, to avoid rebuild the ladder at each harvest, large iron nails are hammered in the *sialang* trunks to make them easier to climb. Collectors also report that since a few years they harvest the nests during the day, protected by mask, gloves and thick clothing. In Ujung Kulon NP, harvest still takes place during night-time. Collectors use a technique they name *sigay rambat*: the collector climbs a more accessible tree in the vicinity of the tree to collect (the harvested tree is called *piodengeun*) and from there throw a rattan rope on the first branches. The climber uses then bamboos to build a rudimentary bridge (*rambat*) to the tree (an ancient harvesting practice which is found also in Borneo and in Palawan).

Once in the tree, the harvesting technique varies little. Collectors want to proceed quickly to harvest the highest number of nests and take advantage of darkness. One or two collectors climb the ladder and once on the first branch start to smoke the colonies using a plant torch (made with the dried roots of *jabai*, *Ficus microcarpa* in Sentarum Lake). When the tree is occupied by several colonies, collectors begin by the highest branches before coming down to the lowest one. Sitting astride the branch, the collector progresses while smoking the surface of the comb with the top of his torch. The majority of bees fly (some will settle on the branches above), but many fall incandescent to the ground (collectors say they follow embers as if it were gold). At the end of the branch, the last comb smoked is the first to be harvested. The climber asks for the collection basket and it is hoisted with a rope. Using a knife (traditionally made of wood, see below) the climber cuts the honey cells and brood (in the four regions, collectors tend now to leave pollen and brood for the next harvest). The collector moves to another branch and the basket is lowered. It is then taken care of by the collectors staying on the ground. The harvest is often teamwork between climbers and collectors below. If at least two people are required (one at the top and the other at the bottom), more than twenty people can participate in the harvest of the trees that host the most nests (over a hundred colonies). In Sentarum Lake, collectors are relatives and each has rights on the *lalau*. Honey is shared between the climber (who takes half) and the heirs. In Ujung Kulon NP, honey or money from its sale is shared equally with the different people participating in the collection.

In Sentarum Lake, the honey planks or *tikung* are placed in the emergent foliage of trees, often facing the hills. The trees are accessible by boat through a small access channel in the forest. As told by the elders, the origin of the planks refers to the observation of a swarm installed under a branch stuck between two trees after a flood. In Belitung, *sunggau* are built in lowland forests near rivers or in mangroves. Occasionally, the collectors also collect combs on various trees (known locally as *sambit*)



they encounter in the forest. Honey trunks are changed regularly (every three or four years) whereas honey planks made preferably of *tembesu* wood (*Fragraea fragrans*) are frequently displaced and can last thirty to forty years. The harvesting method on planks and trunks is not different from large trees, and tools used are the same. In Sentarum Lake the collection takes place at night, but more and more beekeepers try to harvest during the day to allow the bees to rebuild their nest. In Belitung, beekeepers harvest during daytime with a bark smoker (*nyamu*) made of dry branches and fresh leaves which produce abundant smoke. Unlike tall trees, planks and trunks do not always attract swarms. In Sentarum Lake, collectors give an average occupancy rate of one in five in season. In Belitung, harvesters acknowledge that it depends more on blooms and individual expertise: *sunggau* occupancy ranges from one to four (for experienced beekeepers) or one to eight (for those less experienced).

Access to trees as collection sites, but also more broadly the use of natural resources inside a delimited territory, is managed by local rules and/or by customary law. In Sentarum Lake and Tesso Nilo NP, trees belong to old families of collectors. Some harvest them each year, others less often and end up selling their trees to other collectors or for timber or construction lumber. The trees most regularly harvested are maintained: the ground at their base and their branches are cleaned to facilitate the collection, but also for the swarms to settle more easily. In Sentarum Lake, some trees were donated by the local sultan to fisherman families several generations ago (note: some still possess a copy of the document), in return for a tax at each harvest (on wax and honey); other trees, less majestic, have owners but have been harvested since more recently. In general, a tree that hosts a bee swarm for the first time belongs to the person who harvests it, so long as he shows in the future that he takes care of the tree (by some marks or signs). Some owners of a young *lalau* tree, for instance, may try to facilitate its growth by separating it from other trees. In Tesso Nilo NP, if trees are collected for a long time, the regular harvests and the sale of honey have increased their monetary value. In Ujung Kulon, the collected trees do not have owners and anyone can collect the combs from year to year. In the forest, collectors share out between themselves the most suitable sites that they go exploring in small groups of five or six. In Belitung, the first person who comes across a settled swarm in forest owns it and has the (customary) obligation to harvest it (or give the right to someone else to not upset Siti Fatimah, see below). He must mark the location and signal his intention to its neighbours and to the customary authority. Once the comb is collected, the rule applies again the following season.

As for trees and their owners, trunks and honey planks belong to those who build them. In Belitung, as in the lake region of Sentarum, beekeepers report to their neighbours the new locations, sometimes located a short distance from each other. The rule is not to build too close to a structure that does not belong to us, or replace a trunk or a plank of a site because it looks abandoned. Beekeepers often reconstruct the structures in the same location where they have attracted a swarm. In Belitung, the best locations are maintained throughout the year and must meet several criteria. Beekeepers ensure in particular that the trunks are strong enough to support the weight of a comb and vegetation around allows the passage of bees or do not mind the development of the comb (e.g. a branch that strikes the comb). Beekeepers come mostly from the same village and honey thefts are rare. Permission to harvest honey was given to the owner of a *sunggau* (by Siti Fatimah, see below) and a thief will have his belly swollen for his act. An aggrieved owner may use black magic or ask for a customary sanction. In Sentarum Lake, rules and practices concern specific areas and *tikung* owner groups. Areas and groups are called *periau* and correspond to lowland forest areas (flooded in season) limited by rivers and lakes. Formerly attributed by the local authority, sections in each *periau* where *tikung* are installed are family owned and are divided among heirs. Honey planks are marked with notches that allow the various owners to recognize them. Harvesters report several usage rules, e.g. installation of a minimum of *tikung* (25 *tikung* for instance in Leboyan *periau*), the ban on the use of *medang* wood (*Litsea* sp.), obligation to put all its *tikung* in one *periau*, leave an adequate distance between structures (from 10 to 15 meters), and inform the head of the area of the number and location of its *tikung*.

The collectors find that the sites (branches like rafters) are occupied by swarms from one season to another, an observation that makes them say that the bees return to the same location. In Belitung, elders think that bees return to the sites where they were born, hence the need to leave

the first generation (note: the first larvae being laid on the comb, the highest ones) to hatch and to develop into adult insects. If the collectors are looking for new sites, most return on trees previously collected and maintain the sites for the bees to find the exact conditions that saw them coming (or will make them to come back). In all four regions, honeybees are seen as free and mobile resources that one must strive to preserve (as well as their habitat) once they choose a location. In Tesso Nilo NP, as in Sentarum Lake, a story recalls that before choosing a tree, a few bees (the queen bee in TNNP) go down from the branch to the base of the trunk to ask the spirit of the tree if he is strong enough to support them, and if that is the case, the authorization to install their colony in his branch. While swarms are just passing at each new bloom, it is for collectors to appease the spirits of the large trees that annually attract and retain them. In Sentarum Lake, climbers sing mantras at different stages of the collection. When the scale is ready, they welcome its strength. Once on the branch, while smoking the bees, they sing again to appease the spirit of the tree, and when cutting the comb, they welcome the upcoming harvest. Once honey is harvested, they ask their ancestors to protect the basket in its descent. One last song marks the end of the harvest, the final descent of the climbers and the return to the village. Part of the lyrics is improvised, not without humour (often as honey alludes to a beautiful young woman and to her charms) (Mulder et al. 2000). Several myths evoke the mean tricks of the tree spirit, guardian of swarms. In Tesso Nilo NP, as in Ujung Kulon NP, the use of a wooden knife (*suntit* in TSNP, *baliung* in UJNP, *beladaw* in DSNP) can be explained by the ban on the use of iron and iron tools (such as knife) on the top of honey tree and goes back to the story of a climber dismembered by the spirit of the tree. In Ujung Kulon NP, when the climber goes up, a collector remains at the foot of the tree to ensure that a spirit does not follow behind.

In Sentarum Lake, the small trees in which honey planks are attached require no singing, neither mantra, to protect the beekeeper. In Belitung, however, where spirits are everywhere, the use of natural resources (terrestrial and aquatic) within a territory is supported by custom (*adat*) and the village authority (the *dukun kampung*) who acts as an intermediary between villagers and the local spirits. The *dukun* function is to ensure the understanding of his community with the spirits, but also the abundance of resources and their proper use by the group. At an annual ceremony (known as *meras tahun*), he welcomes (economic) resources (those from gardens, but also those from forests and rivers) and never forgets to ask flowers in number for beekeepers. When flowers are there, the *dukun* gives the start of the harvest and prepare the offerings (*jampi*) to spirits. He also intervenes at the request of villagers to repair faults and to restore harmony: after a theft, or when the blooms started but the bees do not come or honey production is limited. In the forest, the collectors are likely to encounter spirits. To ensure their safety, they should thank them and inform them of their intention to cut a tree or take honey. Before building the first *sunggau* of the year, it is customary to ask permission (*kesalan*) to the village *dukun* (and to the spirits). The *dukun* then makes a *jampi* (or activates the one that collectors bring him) and gives to collectors a mantra that they will read in the forest while burning a piece of incense (agar wood usually). In Belitung, mantras as well as customary regulations differ among villages. A popular mantra to drive away the spirit of a tree claims that the trunk one is about to cut belongs to Siti Fatimah and that she shall eat the wax from it (note: Siti Fatimah is the origin of the first *sunggau*, bees feed on her sweat to make honey). Some collectors use private mantras, often inherited ones, to calm bees and avoid stings. Collectors report that in the past *dukun* were more powerful and a village *dukun* could force the swarms installed on another territory to come on his own.

Collectors from the four regions highlight the close relations linking bees to trees and trees to bees. In Ujung Kulon NP in particular, a story relates that bees came from Sumatra after a local mage, Ki Nangkoda, talked to them and made them swear not to damage the trees in the area. More broadly, collectors recognize their own role in the collection of forest resources and highlight the importance of maintaining relationships and appropriate behaviours in their activities. The respect for both trees and bees are reminded through individual and customary rules whose purpose are to maintain balance, but also to satisfy everyone's interests (of spirits, men and bees) and allow bees to come back. In Belitung, beekeepers apologize to the bees before harvesting and ask them not to blame them.



Some say that they develop a relationship of trust with the colony. After smoking out, they use their hands to push the bees from the comb (a collector notices that bees recognize the most caring and gentle beekeepers and do not sting them). Likewise, custom has made patience a virtue. To build and set a honey trunk takes work and the results are random and often do not meet expectations. Beekeepers often try several locations before attracting a swarm. Once the bee swarm is settled, custom in Belitung recommends waiting for the right time to harvest to ensure a sufficient amount of honey but also to allow the colony to grow. The rule is not to take honey before the onset of the first royal cell (*jubel*) (note: and thus allow the bees to swarm and possibly reproduce). A respectful collector will be rewarded in turn by bees (through Siti Fatimah) at a future harvest (note: by the return of the swarm and an abundant production). At the end of blooms, custom recommends taking the brood, since larvae without honey cannot survive, and not to leave out larvae but to eat them.

1.4. Changes affecting insect pollinators and their products

A giant honeybee nest produces on average of six kilos of honey and of half a kilo of wax. Honey had in the past no commercial value and was consumed locally. In all four regions, collectors harvested combs mainly for wax. Honey was consumed on the spot between collectors or brought home. In Sentarum Lake, it was used by the Malays to preserve fish (stored in jars) and to treat minor wounds. The wax being valued, collectors were waiting for the *lalau* and *tikung* combs to be well developed to cut them. They then took the whole comb. The wax was boiled and filtered to form blocks, which were then sold. Until today, the Dayak Iban use local wax to lubricate the threads used in traditional weaving. In Belitung, the *sunggau* were also collected for their wax combs (until the 1950s). Honey was consumed locally or discarded. In the mid-1980s, the price of honey increased to the same price as wax. Honey got expensive from 2009. In 2014, a 250 ml bottle was sold US\$5 by beekeepers and sold back approximately US\$10 in the district capital by the merchants. The quality and preservation of honey is however limited by its extraction process (manual squeezing of the comb). In Sentarum Lake, families exchanged wax with Chinese traders for various goods (salt, tobacco, etc.). Wax was exported, but also sought in Java for its use in the manufacture of batik. The price of honey followed the price of sugar and was very low then. In 1994, a project to develop marketing of honey and wax (to make candles) was initiated with beekeepers. The *tikung* harvesting technique was adapted to allow several harvests (by taking the honey head only and leaving some honey for the bees to reconstruct their stocks). Honey processing was improved with the abandonment of hand squeezing, the practice of filtering, and the use of clean tools and containers. Based on *periau* organization, a local association of beekeepers was created to maintain fixed prices and quality production. Honey is being sold today at seven times more than twenty years ago (US\$10 per kilo), many villagers practice beekeeping (also outside the park boundaries), and even the collection of trees is becoming selective (collectors tend now to leave brood and pollen on the branch).

Three of the four regions (with the exception of Belitung beekeepers who are less organized) have joined the Indonesian Forest Honey Network (*Jaringan Madu Hutan Indonesia*, or JMHI). The JMHI (and its partners) strives to offer honey harvested in a sustainable way (for bees) and quality honey (DSNP honey was the first forest honey in Indonesia to get organic certification). The task is not easy given that forest honey still has the image of a poor quality honey (often processed with water and sugar). Since 2009, the honey harvested by the Sentarum Lake association of beekeepers (APDS) is transported to Pontianak, the capital of the province, before being sent to Jakarta by air-conditioned container where it is filtered again and dehumidified (the degree of humidity being lowered from around 27% to 21%). After processing, the honey is packaged and sold about US\$65 per kilo (mainly in the domestic market). In Tesso Nilo NP, honey collectors are independent and well organized. Their honey production is important and regular (annual potential is estimated at 50 tonnes). Honey is sent to Jakarta, but also to Malaysia to be conditioned. Since 2004, collectors do not collect brood and note that bees come more often on trees. By their own initiative, they harvest honey during the day and no longer smoke the nests to prevent bees absconding. The

association is planting fruit trees in degraded forest areas in the hope of attracting new swarms. In Ujung Kulon NP, honey collectors have created an association and since 2010 have integrated the JMHI. Production is still variable (25 tonnes in 2012, 3 tonnes in 2013).

In Indonesia, natural forest lands decrease to make way for plantations and agriculture. A reality that JMHI shares although many of its members are located in protected areas. In Tesso Nilo NP, a forest company is adjacent to the park, but some *sialang* are on the company concession and collectors have had to negotiate with them to gain access to their trees. Harvesters in Sentarum Lake report that smoke coming from the deforestation of plantations has a direct impact on the arrival of the swarms in season and therefore on honey production (for the years 1997, 1998 and 1999 in particular). Several oil palm plantations were opened in the buffer zone around the lakes since 2004 limiting bee forage areas (18 concessions in total have been granted by the government of the Upper Kapuas regency). Added to this is the fear of the chemicals use in the plantations and transported to the lakes. On Belitung Island, forests are shrinking and are replaced by mines and recently old palm plantations (39 concessions today). Beekeepers have to find other locations and build *sunggau* inside more limited forested areas. Several abandon honey harvesting after the loss of their sites. For lack of forests in their territory, several villages have no more beekeepers working. More broadly, collectors and beekeepers from all regions emphasize the randomness of honey production from one year to the next.

On the contrary, classification as protected area has not only advantages for collectors. In Ujung Kulon NP, the collection is not well received by the park authorities and collectors must negotiate their access with the various administrations. Collectors emphasize that the disappearance of sites is accompanied by a loss of expertise. Whereas in Ujung Kulon NP, young and old are still learning together, in Sentarum Lake experienced climbers are fewer (Iban now call on Malays to harvest *tapang* trees) and few know the songs. Some climbers however try to transmit their knowledge (from father to son usually). The new honey economy also arouses keen interest. In Belitung, in some villages where custom is less strong, beekeepers report theft (harvests done without the consent of their owner). Worried about losing honey from their *sunggau*, some prefer to harvest rapidly (depriving bees of the honey they still need for their development) even though they know that by waiting a bit longer they could get more honey. This is also the case in Ujung Kulon NP where, for fear of losing their chance, those who discover a tree immediately harvest the honey.



Participants of the follow-up meeting during field trip, Belitung, Indonesia, 11 February 2015

Supporting references

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