Submitted to
Indigenous Partnership for Agrobiodiversity and Food Sovereignty: Indigenous Pollinators Network at ITM, INDIA

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Background

Pollinators provide an essential ecosystem service, namely pollination. Indeed, approximately 80 percent of all flowering plant species are pollinated by animals, including vertebrates and mammals - but the main pollinators are insects. Pollination is responsible for providing us with a wide variety of food. Pollinators such as bees, birds and bats affect 35 percent of the world's crop production, increasing outputs of 87 of the leading food crops worldwide, as well as many plant-derived medicines. Pollination is critical for food production and human livelihoods, and directly links wild ecosystems with agricultural production systems.

In Agro-forest ecology, Indigenous pollinators are important agents to up keep the diverse system especially in tropical countries for food, livestock fodder, medicines and livelihood security. More than 69 % of plants both forest plants including wild edibles and agriculture crops are essentially needed diverse pollinators like honey bees species, butterflies, wasps, ants, birds and bats are addition to this essential services. Viable seed quality, grain quality and crop evolution is set through appropriate pollination, which is crucial for regeneration of all plants and genetically diverse.

Usually, the traditional natural landscape, diverse traditional crop diversity, kinds of wood stocks, stumps and field watching huts constructed with bamboo have provided good habitat for numerous pollinators. Usually, these habitats are immediately occupied by solitary bees and revival of vegetation attracts swarms of social bees-pollinators. However, the change in land use, reduction of diverse crops, increased mono crops, extensive application of chemical in farming and deforestation affects the pollinator's diversity.

Objectives of the study and Scope: through initial study and documentation to gain an understanding the diversity of pollinator species including bees, their habitat and their interface with food diversity aspects related to local human populations. This would be followed by various interventions aimed in conservation of the pollinators, bees and their habitat, enhance livelihoods and agro biodiversity.

1. Study Area:

Meghalaya is one of the Seven Sister States of northeast India. It is situated between 25 047'-26010' N latitude and 89045'-92047' E longitude covering an area of 22,429 sq.km. It is consisted of seven districts viz., South Garo Hills, West Garo Hills. East Garo Hills, West Khasi Hills, East Khasi Hills, Ribhoi and Jaintai Hills. Meghalaya is bordered on the Northwest, and East by Assam, South and Southwest by Bangladesh. The indigenous people of Meghalaya include Khasi, Garo and Jaintia indigenous communities who have their respective dialect, distinct ways of life, belief, traditions, cultural heritage and rich plant lore that offer tremendous scope for ethno botanical studies. The state of Meghalaya is mountainous, with stretches of valley and highland plateaus, and it is geologically rich.

Meghalaya has predominantly an agrarian economy with a significant commercial forestry industry. The important crops are potatoes, rice, maize, pineapples, bananas, papayas, spices, etc. The state is geologically rich in minerals, but it has no significant industries. The forest is a montane subtropical moist broadleaf forest ecoregion of eastern India. The ecoregion covers those portions of the Khasi, Garo, and Jaintia hills lying above 1000 meters elevation. Traditionally the tribal communities in Meghalaya have been preserving small patches of virgin forest since time immemorial due to their religious belief. These forest patches, popularly known as sacred groves. It is an agricultural state with about 80% of its population depending entirely on agriculture for their livelihood. A portion of the cultivated area is under the traditional shifting agriculture known locally as *Jhum cultivation*. The study was done in two villages Moosakhia village, West Jaintia Hills and Nongtraw- Wahsohra,East Khasi Hills.

Figure 1. Location of Meghalaya

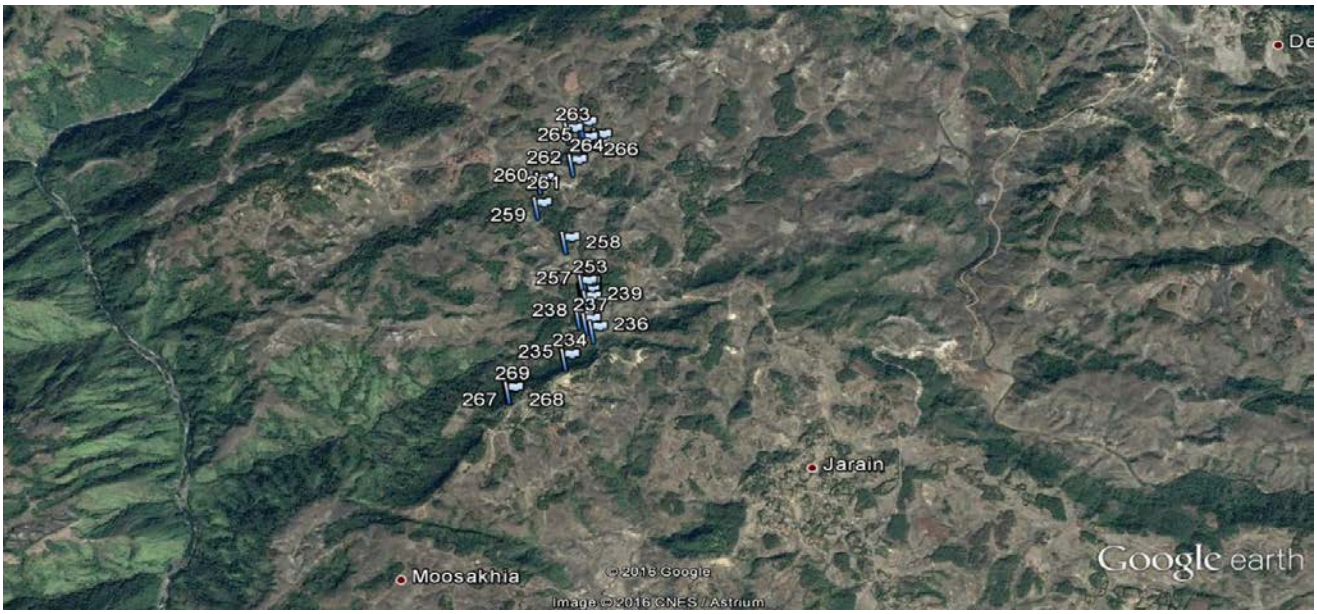

Figure 2. Map of transect laid in Moosakhia

Figure 3. Map of transect laid in Nongtrow

Figure 4. Moosakiya (Above) and Nongtraw (Below)

2. Methodology:

2.1. Floristic diversity

2.1.1 Reconnaissance survey:

A belt transect was planned to record the floristic diversity in the two villages. As the terrain was undulating with steep slopes, reconnaissance survey was done. The survey was conducted covering different zones and landforms such as valley, stream bed, patches of natural forested areas, agricultural lands, jhums fields during the month of March. GPS way points were noted along the route of the survey as different zones were noted. The plants species along the different zones were recorded. Field notes were made on the local name and use of the plant. Plant animal interaction if any was noted down. Foraging of insects on flowering plants were observed and noted. Photographs of plants and insect were taken.

2.2. Pollinator diversity Nongtraw- Wahsohra,East Khasi Hills and Moosakhia village,West Jaintia Hills

2.2.1. Traps:

Traps were set up in the field to collects insects; malaise and pan trap were used to make samples of the insect seen in the area.

i. Malaise Trap: Malaise traps are tent-like traps made of fine mesh material Malaise traps has two short end walls, one central wall, and a roof, which is only peaked on one end, or in some styles, both ends. The walls are generally black and the roof is usually white. Poles were used to support the trap at each corner and at the peak in front. The poles were tied to stakes placed in the ground several feet away. The Insects hits the middle mesh wall and fly either upward or downward. Those insects that fly upward are funnel to the peak of the trap and eventually find their way into a jar with ethyl alcohol in the bottle.

An ideal location was chosen to set the traps. In *Moosakhia* the traps were set in a harvested corn millet field. Nearby was a small kitchen garden with fruit trees, forest, and agriculture land. In Nongtraw - Wahsohra the trap was set up on a fringe of forest and millet fields.

ii. Pantraps: Three sets of pan traps were set up at each site (*Moosakhia* and Nongtraw) and each set consisted of a blue, a white and a yellow pan kept a few feet from each other. Each pan was filled with dilute soap solution and the trapped insects were collected over a period of 24 hours while the traps themselves were kept for two days. Identification was restricted to the family level with species name or morpho-species number assigned to samples where possible. Such a method was decided upon due constraints in time, reference literature as well as group-specific taxonomic expertise available within the stipulated time period for the completion of work. Hence there is scope for further intensive work on specific groups in the future. The specimens collected using both trapping mechanisms as well as

from sweep netting have been preserved in 70% alcohol and available for reference at Keystone Foundation, Kotagiri.

Figure 5a. Malaise Trap in Moosakhia

Figure 5b. Pantraps

2.2.2. Opportunistic sampling: In the method it was made sure not to collect any samples than was extremely necessary and photographic documentation was used to keep the survey as non-destructive as possible.

Figure 5c. Pantraps

2.3. Focus group discussion (FGD): Two group discussions were held with farmers in the evenings in each village. The discussion was on the insects observed by the farmers in their farms. The farmers were encouraged to express their traditional information about insects including season, crop wise observations, time of the day, type of insects and, how the insects do on the flowers and the farmers` understanding of insects and function.

3. Results

Floristic survey:

A total 85 species of plants were recorded from *Moosakhia* and 99 species of plants were recorded in Nongtrow cultivation was observed in both the villages. Very few plants were flowering and the season was yet to start. The species were broadly classified as trees, shrubs, climbers/lianas and herbs.

In Moosakhia the percentages of trees and herbs were 38 and 35%, lianas 16%and shrubs with 7%. Trees were dominant in Nongtrow with 60% followed by climbers and lianas (16%) herbs (12%), Shrubs (9%). Trees were the major source of food for bees and insects and also for edible foods.

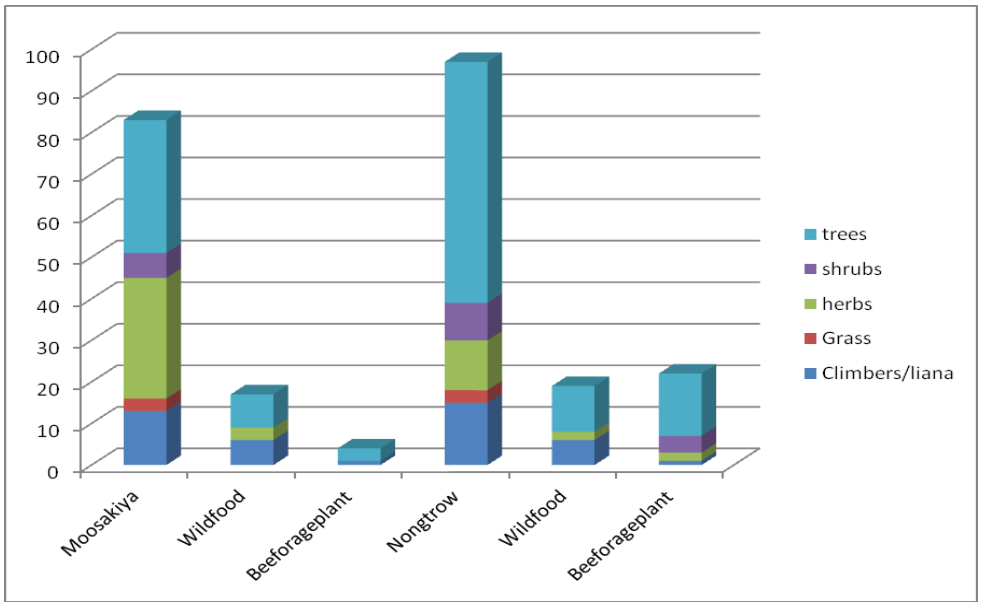

Figure 6. Habit of plant species found in Moosakiya and Nongtrow

Moosakiya had rolling grassland, plateau kind of landscape with paddy fields interspersed and patchy forest. People used the forest `Kher` to collect firewood, wild foods etc. Sand miming was observed in nearby forestlands. Few places were degraded. In Nongtrong the farm lands in the village had planted tree cover had mostly fruit trees. It was also observed that the farmlands were being converted to broomgrass-a kind of reed cultivation. Trees in these farm lands were burnt or systematically eliminated as the grass needed open canopy. During the study , it is observed the main food crops were already Harvested. The study area comprised a mosaic of farmlands with broom grass cultivation, planted trees, forest trees and bamboo groove along the river. Invasive species like Eupatorium was not seen as in coloniser but present.

A transect in *Moosakiya* started nearby habitation (waypoint-234) with a hilly terrain. It was dominant with Bamboo patch at the initial point of transect, with a forest patch along the way. *Soh-phie, Sohpon, Sohbrab, Sohmalein* were the commonly seen species. As the slopes leads to valley a patch of small kitchen garden was noticed with cucurbits, radish, mustard and cauliflower and continues with paddy fields that was harvested. Herbs and Grasses dominated the landscape. The transect continued into a small hillock (waypoint-238). It was a pine (*pinus khasiana* !) dominated, locally called as `Khawkseh`. Kinds of orchids were found abundantly on the trees. Alder, *Dinglakhar, Mahaonia, Soh khawkhoh, Soh-phie, Sohlyngengi, Sohsim* were the tree species found in this forest and at the forest margin *Jasat, shriewkai, Jamaiang* herbs were found. At the forest ended paddy field dominating with yellow forest of anaphalis, strawberry, lindernia sp. and rotula. A similar landscape was seen all along transect. Forest patches locally called as Kher (forest kitchen) was used by the community people to collect fire wood, wild edibles and medicinal plants At one point (waypoint-259) the land was being prepared from jhum

cultivation. Invasive species like Eupatorium was observed along transect as margin of the forest but not as coloniser

In Nongstrow, transect was started in the village. The village is well spread, houses with homestead kitchen garden and fruit trees around with Bamboo patches, Planted tree crops, fruits crops (Lime, mandarin, pineapple) ornamental plants. As the habitation finishes farmlands with broom grass starts (waypoint-284). *Shiah krot, jalyngem, Dieng soh-liya, Soh-ma, soh-mluh, Sohsyrtet, Soh-phie* were the dominant trees found in the transect. The terrain was steep all along the transect. Wohsohra villagewas along the transect *Jayur, Soh-phie, Dieng Sohmluh, Dieng mynthit, Khesaw, Doloi* and many other edible plants. Bamboo patch was seen (waypoint-287) with land being ready for jhum cultivation. The transect ended by the river Wahsohra. In some pockets, broom grass is invasive within food crop like millets, pulses, cereals, potato, tapioca and sweet potato.

Table 1: List of edible plants from Moosakhia and Nongstow

Part used	**Local name of plants**
leaves	Jarain
	Shiahkrot
	Jalynkhany
flowers	Diengphaiur
fruits	Sohpon
	Soh-phie
	Sohmalein
	Sohbrab
	Shoshonben
	Sohlyngengi/ Sohshang
	Sohsim
	Jaiur
	Blackberry
	Sohkjup
	Piskot
	Sopong/Sohlapong
	Siahsohtah
	jalyngem
	Sohsyrtet
	Dieng Sohmluh
	Dieng mynthit
	Solong
	Jali



Figure 7: Sohshiah *sohphon* *Citrus sp.*



Figure 8: Blackberry *Wild banana* *Dieng myntairt*

Insect diversity:

The survey has provided a brief yet encouraging insight into the floral and entomo-faunal diversity of the two locales in Meghalaya despite some of the deterrents such as the season (dry) and the absence of active agriculture during this time of year.

The Pan and Malaise traps aided the opportunistic photo documentation whereby a total of 12 insect orders encompassing at least 39 families and totalling about 78 species were recorded, even going by the most conservative estimate. Among other invertebrates, representatives of at least three families of spiders and one annelid (a leech) were sighted.

The Pan traps were found to be more efficient at trapping hymenopteran species (bees, wasps) than Malaise traps, while the latter seemed to attract more of the dipterans (flies) and lepidopteron (moths and butterflies).

MOOSAKHIA:

Although mountainous, the landscape was one of reasonably gentle rolling hills where our walks covered patches of forest, harvested paddy fields, plots of vegetable cultivation and kitchen gardens with fruiting trees interspersed with grassy patches. Also, our visit being in March, the time of year was

not the most ideal to understand biodiversity that flourished along with their agriculture since the harvest was completed and the season, dry.

Despite the season, the border hedges, ridges were found to be places potentially inhabited by ground nesting bees (solitary or semi-solitary) and wasps.

NONG TRAW:

In comparison to Moosakhia, the Nong Traw landscape had a few more trees and wild plants in flower thus facilitating the sighting or documentation of some pollinator species that were not noticed in Moosakhia, most probably due to the seasonal effect.

INSECT FAUNAL DOCUMENTATION:

Insect representatives from about **12 orders** were recorded during the survey. Over **39 families** were documented totalling more than **78 species**. The number of species mentioned is a conservative estimate since there are some species that remain unidentified.

About **16 species of hymenopteran pollinators (bees, solitary and social), 7 species of dipteran pollinators (hover flies and bee flies), 11 species of butterflies**, not to the mention the splendid diversity of moths, whose diversity only a special exploration can document and a few species of flower visiting **beetles and thrips** were observed from the perspective of pollination services. It is also these four groups that showcased most of the species that were recorded. (Table 2)

Table 2. Major Pollinators (See Figures 9-11)

Location		**Order**	**Family**	**Species**	**Common Name**
Moosakhia		Hymenoptera	Apidae	*Apis cerana*	Asian Honey bee
Moosakhia	Nong traw		Halictidae?	Bee sp1	Sweat bee
Moosakhia				Bee sp2	
	Nong traw		Halictidae	Bee sp3	Sweat bee
Moosakhia			Halictidae?	Bee sp4	
	Nong traw		halictidae?	Bee sp5	
	Nong traw			Bee sp6	
				Bee sp7	
	Nong traw		Apidae	*Ceratina* sp1	Small Carpenter bee
	Nong traw			*Ceratina* sp2	
Moosakhia				*Xylocopa* sp.	Large Carpenter bee
Moosakhia				Bumble bee sp1	Bumble bee
	Nong traw			Bumble bee sp2	

				Bumble bee sp3	
	Nong traw			*Amegilla* sp.	Blue/Black Banded bee
Moosakhia			Megachilidae	Leaf cutter bee sp1	Leaf Cutter bee
Moosakhia		Diptera	Syrphidae	Hover fly sp1	Hover fly
Moosakhia				Hover fly sp2	
	Nong traw			Hover fly sp3	
Moosakhia				Hover fly sp4	
Moosakhia				Bee mimic fly sp1	
Moosakhia	Nong traw			Bee mimic fly sp2	
Moosakhia				Bee mimic fly sp3	
Moosakhia		Lepidoptera	Nymphalidae	*Symbrenthia lilaea*	Northern Common Jester
Moosakhia				*Argynnis hyperbius*	Indian Fritillary
Moosakhia				*Junonia orithiya*	Blue Pansy
Moosakhia				*Neptis hylas*	Common Sailor
	Nong traw			butterfly sp3	
	Nong traw			*Mycalesis lepcha*	Lepcha Bushbrown
	Nong traw		Pieridae	*Pieris brassicae*	Large Cabbage White
	Nong traw		Hesperiidae	*Pelopidas* sp.	Swift, possibly branded
Moosakhia			Papilionidae	*Graphium sarpedon*	Common Bluebottle
	Nongt traw			*Pachliopta aristolochiae*	Common Rose
	Nongt traw		Lycaenidae	butterfly sp10	Blue

Figure 9. (Left to Right) Hover fly sp. 1 to 4

Figure 10. (Clockwise from top Left) Bumble bee sp1, Bumble bee sp2, bee sp3, bee sp2, bee sp1, *Apis cerana*, *Ceratina* sp1.

Figure 11. (Left to Right) Lepcha Bushbrown, Butterfly sp3, A swift, Large Cabbage White

The remaining **8 groups** as well as other members of the above **4 taxa**, despite a few of them serving as **occasional pollinators**, **serve equally important ecosystem services such as predation/parasitism, decomposition of organic matter**, etc., From an ecological as well as agrarian viewpoint, these services are indispensible, for the predators help keep pests numbers low and the **decomposers aid in releasing nutrients to wild plants/crops**. (Table 3.)

Table 3. Other taxa and their functional roles in an ecosystem (See Figures 12-15)

Location		Order	Family	Species/Common Name	Ecosystem Service
	Nong traw	Hymenoptera	Unidentified	Wasp sp1	occasional pollinators, predators
	Nong traw		Unidentified	Wasp sp2	occasional pollinators, predators
	Nong traw		Ichneumonidae	Ichneumonid wasp sp1	predators - parasitoids

Moosakhia	Nongtraw		Unidentified	Many but unidentified	predators – parasitoids
Moosakhia			Formicidae	Black Ant sp1	herbivores, predators
Moosakhia		Diptera		Unknown fly sp1	
Moosakhia			Bibionidae	Plecia sp.*/lovebug	larvae are detritivores; adults are herbivores
	Nong traw		Sarcophagidae	Unidentified fly sp3 /flesh fly	decomposers
	Nong traw			Unidentified fly sp4	
	Nong traw		Asilidae	Robber fly sp1	predators
Moosakhia			Calliphoridae	Blow fly sp1	larvae - decomposers/scavengers; adults - occasional pollinators, esp. of plants that produce smell of rotting meat
Moosakhia	Nong traw		Muscidae	Muscid /House flies	predators/decomposers
Moosakhia		Coleoptera		Beetle sp1	
Moosakhia			Cerambycidae	Beetle sp2 / Long Horned beetle	adults - herbivores; larvae - wood borers and potential pests of trees
Moosakhia			Coccinellidae	Lady beetle pupa sp1	predators as larva and herbivores/predators as adult
Moosakhia				Beetle sp3	
Moosakhia			Coccinellidae	Lady beetle sp1	predators as larva and herbivores/predators as adult
	Nong traw			Beetle sp4	
	Nong traw			Beetle sp5	
	Nong traw		Curculionidae	Weevil sp1	herbivores, each species with narrow host range (mono or oligophagous)
Moosakhia			Staphylinidae	Rove beetle sp1	predators
	Nong traw			Beetle sp6	
	Nong traw		Cantharidae	Beetle sp7 / Soldier beetle	adults - harmless, larvae & adults both useful predators
Moosakhia			Elateridae	Beetle sp8 /Click beetle	adults - herbivores; larvae - detritivores/decomposers
	Nong traw			Beetle sp9	
Moosakhia		Hemiptera	Aphididae	Black winged aphid	herbivores, possible pest
Moosakhia				Bug sp1	
Moosakhia			Cicadellidae	Plant hopper	herbivores, possible pest

	Nong traw		Membracidae	Tree hopper sp1	herbivores, possible pest
	Nong traw			Bug sp2	
Moosakhia			Gerridae	Water strider sp1	surface predators in aquatic ecosystems
Moosakhia				Bug sp3	
Moosakhia		Dictyoptera		Wood cockroach sp1	detritivores/decomposers
Moosakhia		Orthoptera	Acrididae	Short horned Grasshopper sp1	herbivores
Moosakhia			Acrididae	Short horned Grasshopper sp2	herbivores
Moosakhia		Phasmida		Unidentified walking stick	herbivores
Moosakhia	Nong traw	Dermaptera		Earwig sp1	herbivores, predators
	Nong traw	Thysanoptera		Thrips sp1	predators, pests, pollinators
	Nong traw	Plecoptera		Stonefly sp1	Important indicators of water quality. Stoneflies are very sensitive to water pollution; nymphs may be herbivore/predators adults either do no feed or are herbivores
Moosakhia		Collembola		Springtail sp1	detritivores/decomposers
Moosakhia				Springtail sp2	
Moosakhia				Springtail sp3	

Figure 12. (Left to Right) Beetles - Beetle sp6, Beetle sp1, Beetle sp2, Lady beetle sp1.

Figure 13. (left to Right)True Bugs - Bug sp1, Bug sp2, Tree hopper sp1, Aphid sp1 (winged form).

Figure 14. Wood Cockroach sp1, Black ant sp1, Short Horned Grasshopper sp2, Walking Stick sp1.

Figure 15. Exuviae of stone fly found on rocks in Wah Sohra river.

OTHER INVERTEBRATES:

A couple of other invertebrate taxa were also observed namely a leech and few species of spiders. (Table 4.)

Table 4. Other Invertebrates (See Figure 16)

Location		Phylum	Class	Order	Family/Common Name	Species	Ecosystem Service
Moosakhia	Nong traw	Arthropoda	Arachnida	Araneae	Oxyopidae – Lynx spiders	Spider sp1	predators
Moosakhia			Arachnida	Araneae	Lycosidae – Wolf spiders	Spider sp2	predators
Moosakhia			Arachnida	Araneae		Unidentified spider sp1	predators
Moosakhia			Arachnida	Araneae		Spider unidentified sp2	predators
Moosakhia				Araneae	Thomisidae – Crab spiders	Crab spider sp1	predators
	Nong Traw	Annelida	Clitellata SubClass: Hirudinea			leech sp1	Ecto-parasites/predators

Figure 16. (Left to Right) Wolf Spider, Lynx spider, Unidentified spider sp1.

Figure 17. Nest holes of Solitary bees.

Focus group discussion (FGD):

Four group discussions were held with farmers in both Moosakia and Nongtraw villages in the evenings. The discussion was on the insects observed by the farmers in their farms, types of insects, how they look this process with traditional wisdom and the association of insects and understanding in farming.

Moosakhia:

While discussion, people have expressed that they all have briefly noticed that there are birds, butterflies, bees and various insects constantly visits/sitting on flowers and flower to flower. All farmers had different opinion on insects visiting the flowers. It was interesting to know about their perception on insect visitation. Some believes that the insects visit flowers as a source of food. They were also happy when the insect visit the flowers as they feel that it brings in some kind of connection between them. Few farmers were not happy on insects visiting the flowers as they feel that the insect lays eggs on the flowers, which later gets inside the fruit. Few framers were happy when the bees visit the flowers and but not happy when other kinds of insects visiting crop. Most of the beekeepers believe that they get honey from hives as in returns, as others are competitive to bees. Interestingly no one observe or understands or noticed the nesting information of other insects. They have observed that the flowering buds in the same tree do not bloom fully few open and few are closed. They insects visit the flowers of one tree to another. They understand that there is some “transfer” happening between the flowers. The farmers want to understand the science of pollination and fruit set. They feel that if the frequencies of

visitation is more the quality of fruits are good and when there is no visitation, there is no fruit set. It is termed as "*thoughravu" by* the people.

Some farmers were also practices log hive beekeeping except one individual who uses a newton hive very recently and the discussion started on beekeeping methods in the village. The farmers harvest 2-3 kgs of honey from log hives that was placed randomly in their farms lands. They sell it as squeezed honey and some time as honey combs. The honey is usually harvested during the month of November-December. The honey is not harvested during the month of March - April as the honey has a bitter taste. This honey is left for the bees to feed on during the dearth season. The log hives is made from the wood of *Sohmyllang, Dieng-ngan* and *Dyengsyndoh*. As they have observed colonies found naturally in the cavities of these trees. While capturing the colonies the mouth of the cavity is enlarged and the colonies are placed in log hives.

Figure 18: Beekeeping in Mooshakiya

As a tool to explain pollination to the farmers we drew a flower of a cucumber as it was one of the main crops being cultivated by them. The parts of the flower were labelled. The process of pollination and the role of insects visiting the flower were explained. The farmers expressed that they were not aware of the science of pollination process and it importance. Through this exercise, basics of pollination are understood and would not disturb the insects while they forage. They were happy that their bee visitation had an important role and with other insects.

Figure 19: Discussion with farmers at Mooshakia

Nongtrow: The farmers were also beekeepers and the discussion started on beekeeping methods in the village. The farmers harvest 3-4 kgs of honey from log hives that was placed randomly in their farms lands in the village. The honey is usually harvested during the month of November-December. The honey is not harvested during the month of March – April as the honey harvested from the blooming of *Lajumai* (Eupatorium sp) has a bitter taste. Due to torrential rain during May-July the bees cannot forage for food, the honey is left for the bees to feed on during these seasons. The flowers of black berry (*Prunus nepalensis*) provide a major source of food for bees and they believe 80% of the bee food is from this tree. The beekeepers have experimented hives making it from wood and cement. Cement/concrete hive were made as *Phyllad*(martin) raids the honey combs and causes damage to wooden hives. The longevity of the concrete hives is estimated for about 40years. Log hives were made from *Dieng sing, Dieng lakhaiat* as the natural colonies were found in the cavities of such tree species trees. All farmers believe that the number of colonies in the forest have been reducing constantly over the decade in as the forage area/trees are declining due to broom grass cultivation.

Figure 20: Beekeeping in Nongtrow

To discern their understanding on insect visiting flowers few questions were asked to farmers. The farmers believe that the insects visits the flowers to collect food but do not understand what kind of food the insects collect. They flowers are a stage or platform where the entire insect come to meet each other, exchange their thoughts, and talk to each other. They also assume that the flowers that are showy are prone to insect attack and flowers that are not showy or beautiful are safe from insect attack. They have also observed birds visiting flowers other than insects. The feel that it is important that the insect visit the flowers that helps in setting of seeds. The farmers sited an example of insect visitation on the flowers of *Dieng Soh-Jallu*.

Figure 21: Discussion with farmers at Nongtrow

The farmers had listed plant species that are visited by insects according to the seasons (*Iyam*).

Table 5: Plants visited by insects according to seasons (*Iyam*).

Seasons (*Iyam*)	**Plant species visited by insects**
Autumn (Sep-Nov)	Trees: Blackberry, Dieng-Khasari, Soh-khyllam, Pyrshit, Soh-shang, Dieng Jakarai, Shitmuid, Soh-lyngwai, Jyllngap Grasses: Prout, Kdrait
Winter (Dec-Feb)	Trees: Dieng jup, Dieng jalu Climber: Disohjalyndem
Spring (Mar-May)	Trees: Syrtet, Lakhar, Soh-phon (plum), Soh-pherem (peach), Mandarin, Wild lemon, Soh-mad, Soh-madgong, Soh-pie, Dieng ngan, Lympied, Lyllmut, Soh-spat, Soh-sorat, Jylngiem Climber: Kynsew Shrub: Lajumai, mustard
Summer (Jun-Aug)	Climber: Mejyrmynruin, soh-khawiang

Case study: 1

Stanely Dkhar, aged 42, father of 8 children resides Samanong, West Jaintia practices Agriculture and Log hive beekeeping. He owns 27 log hives and 14 are occupied with bees. Collects about 45-55kg squeezed honey and sold through agent and locally. Usually collects swarms and feral colonies in Sep-Oct and transfer to logs after clipping of the wings of Queen Bee. Also keep bait hives in forest for swarms. He carves himself log hive which takes 3-5days, estimated value of Rs.1200. He sells squeezed and filtered honey @ Rs.500 and 400 for comb honey in Jowi town. Wax is never extracted in fact unaware.

Pollination-he is well aware of pollination by bees and not aware of other pollinating agents. Sprays pesticide in vegetable and paddy cultivation.

Case study: 2

Lawrence, aged 60 hails from Mookhasia practices beekeeping with Newton hives and Log hives. They identify honey from Eupatorium(male) is not consumed which is traditionally believed to be toxic. The pollen is never eaten. He prefers the newton hive to keep bees rather logs, feel easy inspection & management.

He accepts bees are pollinators but no other agents.

Case study: 3

Stephen Diengdoh, resides in Nongtraw, practices beekeeping in Concrete & tin insulated hives. Has lost many colonies to Matin-wild animal raids honey and combs, also damage wooden hives. He produces about 50kg and sells to Women enterprise group-Nongtraw and other villages. Tree cavities are shaped to attract bees and transfers to concrete/insulated wooden hives later. The major volume of honey is harvested in Sep-December. Thrice swarms are obtained in a year. The biodiversity is reducing and honey production has effects. Three cycles of extraction is reduced to two times.

Pollination-though he knew pollination science, he is not aware of other than bees.

General observation:

- In Moosakiya, forest patches called as *Kher* were used by community people for collection of firewood, wild edibles raw as well to cook and medicinal plants. The understory of the forest looked disturbed due to collection activities.
- The stream side forest patches are primary, natural, diverse and contiguous, also isolated/fragmented patched of pine and mixed is observed on raised land.
- Some pockets of natural forests are strictly maintained as sacred groves by community.
- Invasive species-eupatorium was found on the margins of the forest.
- Sediment loads were observed in the valley where paddy cultivation is being done.
- Slash and burn is practiced in the village.
- Wild animal sighting /secondary were not observed. Sighting of birds were few.
- Mining of limestone was observed adjacent to the village. The mining was done from the base of the hill resulting in tunnels leaving a layer of soil on which the plants were growing. In certain places, the whole hill was cleared resulting in loss of grassland, forest patches.
- In Nongtrow the village looked green as there were trees planted in the village farmlands.
- Broom grass cultivation is invasive into traditional food farming lands, jhum(Slash and burn) was practiced in the village.

DISCUSSION & END NOTES

Insect representatives from about **12 orders** were recorded during the survey. Over **39 families** were documented totalling more than **78 species**. The number of species mentioned is a conservative estimate since there are some species that remain unidentified.

About **16 species of hymenopteran pollinators (bees, solitary and social), 7 species of dipteran pollinators (hover flies and bee flies), 11 species of butterflies**, not to the mention the splendid diversity of moths, whose diversity only a special exploration can document and a few species of flower visiting **beetles and thrips** were observed from the perspective of pollination services. It is also these four groups that showcased most of the species that were recorded.

Most of the prominent Hymenopteran pollinators documented in both are solitary despite the season not being the most ideal in terms of choice food resources, availability of water and climate. The importance of **solitary bees is being more and more recognized all over the world for their pollination services. Solitary bees are either nest in the soil (ground-nesting, Figure 17) or make galleries in**

wood/tree trunks and branches. Therefore micro habitats such as hedges and undisturbed open patches of ground will serve beneficial both to bees as well as us. In Moosakhia as well as Nong Traw, the needs of such are met with which is a happy finding for the bees are found to be in reasonable numbers.

Social bees such as ***Apis*** **sp. which live in large colonies or the bumble bees which live in much smaller colonies, require adequate nesting resources such as tree holes, etc., to meet their nesting requirements.**

The traditional log hive keeping is a strong activity

Role of **flies as pollinators is generally overlooked but they do offer considerable degree of pollination services.** Dipterans such as hover flies and bee mimic flies were found in abundance especially in Moosakhia.

Another important observation was that of stoneflies (Figure 15) near the waters of the Wah Sohra river. Stoneflies are critical biological indicators of water quality in aquatic ecosystems as they are very sensitive to pollution and other physico-chemical changes of aquatic systems. Numerous stonefly exuviae were found all along the rocks and boulders on the river indicating that the water in the river is of good quality.

Pollinators aside, a reasonable mix of herbivores (some of which are potential pollinators such as some wasps, thrips, beetles, etc.), predators, parasitoids, detritivores and decomposers were also documented all of whom project a healthy ecological scenario in the surveyed sites. However, steps need to taken to reduce/avoid usage of chemical fertilizers and pesticides. The chemicals may provide immediate relief for the farmer but the relief would be very short-lived and at the cost of his health and finances as the pests would return the next season, with probable resistance to the chemicals sprayed. Thus ensuring traditional know-how, cultural and mechanical agrarian practices are to be revived and kept alive and well to ensure that all ecosystem partners in the system are present for our well-being as well as the well-being of the ecosystems around us.

Where to next?-Recommendations

Opportunities	Action plan
1. Dissemination of information to farmers	Sharing pollinators diversity observed through this study,
2. Pollinators promotion and conservation	Prepare a brief pollination & pollinators information in local language about pollinating agents, role, conserving & promoting habitats, restoration across different region
3. Knowledge building(with relevance to traditional), management and sustainability	Training and capacity building among farmers and enhance organic efforts
4. Biodiversity promotion & conservation of native species.	Establish plant nurseries of diverse tree, shrub, spice to increase biodiversity and for income. Grassland can be enhanced by growing flowering species which can provide cover for invertebrates and source of nectar for insects. Edible plants can be grown in degraded lands, farm lands and as hedges Trees can be grown as hedgerows, shoreline of
5. Building farmers institution and governance	Train lead farmers and NESFAS team to map all pollinators across 39 villages in Meghalaya during October to December(over 3 years)
6. Enhance crop production and income through honey & wax production	Parallel effort to promote appropriate bee keeping enhancing crop pollination/productivity and income from honey and wax. Bee forage plants can be raised in nursery and planted in suitable lands.
7. Enterprise development-building organic market- brand building, “Organic by Tradition”	Organise training for value addition of honey, wax, organic products and create Organic shop
8. For future generation	Publish a complete Book on pollinators of Meghalaya and farmers’ book

Annexure 1.

Table showing complete list of document insect groups and their functional roles (H=Herbivore, P=Pollinator, Pr=Predator, Pa=Parasitoid, Dt=Detritivore, Dc=Decomposer)

Location		Insect Group	Common Name	# Families	# Species	Families	Functional Guild			Remarks
							H	Pr	Dt/Dc	
Moosakhia		Collembola	Springtails	3	3				Dt/Dc	
	Nong Traw	Thysanoptera	Thrips	1	1		Hp	Pr		Possible pests
	Nong Traw	Plecoptera	Stoneflies	1	1		H	Pr		H/Pr - nymphs; adults either do no feed or are herbivores. **## Stoneflies are very sensitive to water pollution; thus very important indicators of water quality**
Moosakhia		Dermaptera	Earwigs	1	1		H	Pr		
Moosakhia		Dictyoptera	Cockroaches	1	1				Dt/Dc	
Moosakhia		Orthoptera	Grasshoppers, Crickets, Katydids	1	2		H			
Moosakhia		Phasmida	Walking Sticks	1	1		H			
Moosakhia		Hemiptera	True bugs	4+	7	Cicadellidae	H			possible pest
	Nong Traw					Membracidae	H			possible pest
Moosakhia						Aphididae	H			possible pest
Moosakhia						Gerridae		Pr		
Moosakhia	Nong Traw					**Unidentified**	**H**	**Pr**		
Moosakhia		Coleoptera	Beetles	6+	12	Cerambycidae	H			larvae - wood borers and potential pests

										of trees
Moosakhia						Coccinellidae	H	Pr		Pr – larva; H/Pr - adult
	Nong Traw					Curculionidae	H			each species with narrow host range (mono or oligophagous)
Moosakhia						Staphylinidae		Pr		
	Nong Traw					Cantharidae		Pr		Pr - larvae and adults
Moosakhia						Elateridae	H		Dt/Dc	H - adults; Dt/Dr - larvae
						Unidentified	**H**	**Pr**	**Dt/Dc**	
Moosakhia	Nong Traw	Lepidoptera	Butterflies	5	11		Hp			Larval stages could be pests
			Moths	2+			Hp			Larval stages could be pests
			Caterpillars		6	Unidentified	H			possible pest
Moosakhia	Nong Traw	Diptera	True flies	6+	12+	Syrphidae	Hp			
Moosakhia						Bibionidae	H		Dt	Dt – larvae; H - adults
	Nong Traw					Sarcophagidae			Dc	
	Nong Traw					Asilidae		Pr		
Moosakhia						Calliphoridae	H		Dt/Dc	Dt/Dc – larvae; adults - occasional pollinators, esp. of plants that produce flowers with smell of rotting meat

Moosakhia	Nong Traw					Muscidae		Pr	Dc	
						Unidentified	**H**	**Pr**	**Dc/Dt**	
Moosakhia	Nong Traw	Hymenoptera	Bees, Wasps, Ants	7+	20+	Apidae	Hp			
Moosakhia						Megachilidae	Hp			
Moosakhia	Nong Traw					Halictidae	Hp			
Moosakhia						Unidentified bee	Hp			
	Nong Traw					Ichneumonidae		PrPa		
	Nong Traw					Unidentified wasps	H	Pr		
Moosakhia	Nong Traw					Parasitoid wasps		PrPa		
Moosakhia						Formicidae	H	Pr		

Annexture 2.

Table showing other invertebrates documented with functional role

Location		Group	Common Name	# Families	# Species	Families	Functional Guild			Remarks
							H	Pr	Dc/Dt	
	Nong Traw	Annelida	true worms - earthworms, leeches, etc	1	1	Unidentified leech		Pr		Predators/Parasites
Moosakhia	Nong Traw	Arachnida	Spiders, scorpions, mites, ticks	3+	5+	Oxyopidae		Pr		
Moosakhia						Lycosidae		Pr		
Moosakhia						Thomisidae		Pr		
Moosakhia		Amphibia	frogs, toads, salamanders	1	1			Pr		

Annexture 3.

List of Plants species in Moosakhia

S.no	Localname	Habit	Botanical name	Use
1	Shken	Bamboo	Bambusa pallida	Bamboo used for making baskets
2	Shken	Bamboo		
3		Climber	Aristolochia	
4	Sohbrab	Climber	Passsiflora edulis	fruits edible
5		Climber	Smilax aspera	
6	Shiahkrot	Climber	Smilax perfoliata	leaves edible, root medicinal
7		Climber	Rubus ellipticus	fruits edible, Bee forage plant
8		Climber	Rubus niveus	fruits edible,leaves aid in digestion
9		Climber	Stephania	
10	Wild rose	Climber		
11		Climber	Pepper	
12	Jaiur	Climber	Zanthoxylum	fruits edible
13	Sohlyngengi	Liana	Elaeagnus latifolia	Fruit edible
14	Dicranopteris	fern	Dicranopteris	
15	Broom grass	Grass	Thysanolaena maxima	
16		Grass	Grasses	
17		Herb	Acanthaceae	
18	Anaphalis	Herb	Anaphalis	
19	Begonia	Herb	Begonia	
20	Khliang syiar	Herb	Centella	medicinal
21	Smakhong	Herb	Eupatorium adenophora	bee forageplant, leaves medicinal
22	Smakhong	Herb	Eupatorium linearifolium	Bee forage plant
23	Jarain	Herb	Fagopyrum esculentum	leaves edible
24	Tyrkhany	Herb	Ferns	
25		Herb	Gentiana	
26	Khawainj	Herb	Hedychium	roots used in brewing liquor
27		Herb	Hydrocotyle	
28		Herb	Impatiens	
29		Herb	Lindernia	
30	Wild banana	Herb	Musa acuminata	fruits edible
31	Sohteiw	Herb	orchid	
32	Oxalis corniculata	Herb	Oxalis corniculata	
33	shriewkai	Herb	Plantago	bee forage
34		Herb	Polygonum	underground stem and flowers edible
35	Rotala	Herb	Rotala	
36	Sohkhyndew	Herb	Fragaria	friut
37		Herb	Urena lobata	
38		Herb	Verbena venosa	
39		Herb	Vernonia	
40		Herb	Viola	
41		Herb	Wahenbergia	
42	Wild banana	Herb	Musa acuminata	
43		Herb	Gentiana	
44	Bidens	Herb	Bidens	
45	Spilanthes	Herb	Spilanthes	

46		Shrub	Breynia retusa	
47	Smakhong	Shrub	Eupatorium adenophora	
48		Shrub	Lantana	
49	Soh khawkhoh	Shrub	Maesa indica	Bee forage plant
50	sludong	Shrub	Osbeckeia	
51		shrub	Solanum xanthocarpum	medicinal
52	Dingngan	Tree		bee cavity, wood used to make body part of trucks
53	Alder	Tree	Alder nepalensis	
54	Jatyrsim	Tree	Debregesia longifolia	fibre taken from the stem
55	Sohpon	Tree	Ficus	fruits edible
56		Tree	Lauraceae	
57	Sohmed	Tree	Lime	fruits edible
58	Dinglakhar	Tree	Macaranga	
59		Tree	Mahonia	
60		Tree	Meliosma	
61	Soh-phie	Tree	Myrica esculenta	fruits edible
62		Tree	Tertrapanax paprifer	
63	Mumkesh	Tree	Pinus kasiana	
64	Sohthing	Tree	Rhododendron	
65		Tree	Saracocoa	
66		Tree	Scheffelera	
67	Sohmalein	Tree	Syzygium	Fruits edible, timber value, loghive made fromwood
68		Tree	Tertrapanax paprifer	
69		Tree	Vernonia arborea	
70	Wild oak	Tree	Quercus	
71	wild peach	Tree	Prunus persica	
72	Diengshing	Tree		Bee forage plant
73	Iyba	Tree		Firewood, timber
74	Diengphaiur	Tree		flowers edible, cooked with fish, meat; medicinal
75	sohajup	Tree		Bee forage plant
76	Lympiek	Tree		
77	Sohsim	Tree		fruit edible
78	Sohkyup/Shynrang	Tree		
79	Ligustrum	Tree	Ligustrum	
80	Neolitsea	Tree	Neolitsea	
81	Lympiek	Tree		
82	Dingan	Tree		
83	Jali	Tree		edible plant
84	Ksehum	Tree		
85	Kain			

Annexure 4.

List of Plant species in Nongtraw

S.no.	Local name	Habit	Botanical name	Use
1		Climber	Colchicum	
2		Climber	Rubus	
3	Sohshang	Climber	Elaegnus	friuts edible
4	Piskot	Climber	Seschum edule	fruit a vegetable
5	Kanup	Climber	Entada	
6	Siahsohtah	Climber	Rubus ellpiticus	friuts edible, bee forage, leaves medicinal
7	mimynruin	Climber	Tetrastigma	
8	Shiah krot	Climber	Smilax perfoliata	roots brewed as tea
9	Shoshonben	Climber	Passsiflora gigantica	Fruits edible
10		Climber	Wild pepper	
11	Jayur	Climber	Zanthoxylum	fruits edible
12	Khesaw	Climber	Dolichus	
13		Climber	Elaegnus latifolia	
14	Doloi	Climber	Beetle leaf	
15	Kapadong	Climber	Monstera	
16	synsar	Grass	Thysanolaena maxima	medicinal, used as broom
17	Shken	Grass	Bambusa pallida	basket making
18	Shken	Bamboo	Bambusa	
19	Batrben	Herb	Kalanchoe	leaves rubbed to heal burns
20	Kaitmon	Herb	banana	bee forage plant
21	Kaitkhar	Herb	banana	bee forage plant
22	Khawianj	Herb	Hedychium	roots used in brewing liquor
23		Herb	Vernonia	
24	Sohturn	Herb	Ananas comosus	
25	Jalynkhany	Herb		tender leaves eaten raw
26	jalyngem	Herb	Polygonum	friuts edible
27		Herb	Elastomma	
28		Herb	Hedychium	
29		Herb	Ananas comosus	
30		Herb	Acanthaceae	
31	slamet	Herb	Phrynium pubinerve	leaves as packing material, fibre taken from stem
32	Smakhong	Shrub	Eupatorium linifolium	
33	Soh khawkhoh	Shrub	Maesa indica	
34	Tieawjain	Shrub	Shoe flower	bee forage plant
35	Batjumai	Shrub	Eupatorium odarata	
36	Soh khawkhoh	Shrub	Maesa indica	bee forage plant
37	Smakhong	Shrub	Eupatorium adenophora	bee forage
38	Tiewlich	Shrub		bee forage
39	Jaktuh	Shrub	Osbeckia	
40	Jakhi	Shrub	Stenosiphnum	leaves fed to pigs
41	Brinjal	Shrub		

42	Smakhong	Shrub	Eupatorium adenophora	
43	Sophan	Tree	Artocarpus heterophyllus	
44	Jating	Tree	Albizzia	bee forage
45	Naingmuin	Tree	Alstonia scholaris	
46		Tree	Blackberry	fruits edible
47		Tree	Bumlemoss	
48	Dieng lakhiot	Tree	Callicarpa arborea	log hive made from this wood
49	Caryota	Tree	Caryota urens	
50	Latyrshom/latyrpad	Tree	Cinnamomum tamala	leaves used a condiments
51	Sohmad	Tree	Citrus medica	lime
52		Tree	Debergesia	
53		Tree	Deing sohku	
54	Dieng song	Tree	Erythrina arborescens	bees and birds forage on flowers, medicinal
55	Sopong/Sohlapong	Tree	Ficus	fruits edible
56	Khariew	Tree		
57	Dieng tyrthia	Tree		bee forage plant
58	Mangkaring		Loranthus	
59		Tree	Macaranga	
60		Tree	Mallotus	
61	Sohjarem	Tree	Mappia	medicinal
62		Tree	Michelia	
63	Sohsoirete	Tree	Morinda	
64		Tree	Mulberry	
65	Soh-phie	Tree	Myrica esculenta	fruits edible
66	Papaya	Tree	Papaya	
67	Peach	Tree	Peach	
68	Khehkhasi	Tree	Pinus kesiya	
69	Dieng-iongkrem	Tree		
70	Dieng kashari	Tree	Prunus cerasoides	bee forage plant
71	Sohiong	Tree	Prunus nepalensis	
72	Sohpri	Tree	Psidium guajava	Bee forage plant
73	Dieng shing	Tree	Quercus semicarpifolia	
74	Soh-ma, soh-mluh	Tree	Rhus semialata	bee forage
75		Tree	Vernonia arborea	
76	Deing Jakrai	Tree		
77	Sohsarat	Tree		
78	Lapatha	Tree		leaves extraxt is used to treat snake bite
79	Ksehblei	Tree		
80	Sohsyrtet	Tree		flowers medicinal, fruits edible
81	Sohkjup	Tree		fruits edible
82	Dieng soh-jalu	Tree		Bee forage plant, bark medicinal used to treat artritist
83	Dieng phylloet	Tree		bee cavity tree, bark use to stun fish
84	Kdait	Tree		bee forage plant, honey is yellowish and tastes very good
85	Jatyrsim	Tree		bee forage plant, bee take water from the leaves
86	Jakaari	Tree		bee forage plant
87	Dieng ngan	Tree		bee cavity
88	Jylngap	Tree		bee forage
89	Pyrshit	Tree		bee forage
90	Shitmuit	Tree		
91	Mandarin	Tree		

92	Sohthiang	Tree		
93	Dieng lakhan	Tree		bee forage, used as fuelwood
94	Dieng soh-liya	Tree		fruits edible, bark used to stun fish
95	Pyrshit	Tree		
96	Dieng Sohmluh	Tree		fruits edible
97	Dieng mynthit	Tree		fruits edible
98	Pomolos-Walaneia	Tree		
99	Solong	Tree		fruits edible