AGRICULTURAL SCENARIO VIS-A-VIS THE POLLINATOR ELEMENTS OF THE SIKKIM HIMALAYAN REGION

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ABSTRACT

For the Sikkim Himalayan region the bees, butterflies, flies, beetles and mammals are found to be important pollinator elements and also the mediator of gene flow and the resultant transformation in local flora. Common native species of bees are *Apis cerana* subsp. *cerana, A. cerana* subsp. *himalayana, A. dorsata,* and *A. laboriosa,* as well as the less noticed threatened species of stingless bees, viz., *A. floriea* (locally known as *Kathyauree*) and *Trigona* sp. (*Putka*). Although *Apis mellifera,* a native of Europe has been introduced to promote bee-keeping in the Himalayan region it has so far not outbred with or displaced the local species. The dwindling figures of bee hives and wild colonies of bees have been traced to the cause of lowering crop production in the region but it may not be the root cause as several factors, as equally important, are involved here. Immediate and serious conservation efforts are suggested for the few but important pollinator species of the region.

KEYWORDS: *Pollination, agriculture, large cardamom, honey bee, Sikkim Himalaya*

Traditional bee-keeping in Darakharka, South Sikkim

Bumble bees are social insects belonging to the bee genus Bombus in the family Apidae

INTRODUCTION

Sikkim is a Himalayan state with mountainous topography falling under the catchments of Tista and Rangit rivers which originate from glaciers or high snow areas. An altitudinal range of 300-8, 598 m within a short horizontal expanse of c.120 km aerial distance forms different ecozones, e.g., from subtropical to alpine climatic zones. Sikkim has an area of 7,096 km^2 and a population of 4.5 lakh with an average density of 76 persons per km^2 (Census 2001). The region falls between $27^0$4'46" to $28^0$7'48" N and $88^0$58" to $88^0$55'25" E with an altitudinal variation from 300 m at the foothills to 8548 m at the peak of the Mount Khangchendzonga. Nepal bound it on the west, on the north by Tibet, on the east by Bhutan and Tibet, and with the Darjeeling district of West Bengal stretching along its southern boundary. Sikkim Himalaya is endowed with an extraordinarily rich biodiversity. Variations in biogeography and changes in altitudes over short distances have combined to form a region with a great wealth of natural ecosystems. Average annual rainfall varies from 1,300 mm at the valleys to 4,300 mm at the mountain ridges, and 60-75% of this rain falls during the monsoon season, i.e., June through September. The humidity remains very high during the rainy season (85-97%). The state is regarded as a hotspot for biodiversity. It is rich in cultural diversity with distinctive ethnic groups such as the Lepchas, Bhutias, Nepalese and Limbus.

The agriculture sector in Sikkim accounts for about 67 per cent of the workforce. Many of the horticultural and cash crops depend upon pollinators. Promoting conservation and management of naturally occurring insect pollinators is very important for sustaining agricultural productivity in the long run. This is necessary in order to underline applied research in key areas of managed crop pollination. Issues such as decline of pollinator populations and the need to conserve them have become key issues which requiring timely intervention to safeguard the food security situation.

Agro-ecosystem characterization

Mountain agriculture in Sikkim comprises of traditional methods both for the food grains and cash crops. Cash crops such as cardamom (*Amomum subulatum*), mandarin orange (*Citrus reticulata*), ginger (*Zingiber officinale*) and potato (*Solanum tuberosum*) are extensively cultivated here. Large cardamom is the major cash crop of Sikkim and its cultivation has been confined to the eastern Himalaya (Sharma *et al.* 1998, 2000). Its fruit (capsule) is used as spice/condiment and sometimes used to prepare vegetable dye. It is a low-volume: high-value and non-perishable perennial cash crop. Other than Sikkim, Darjeeling hills in West Bengal of India, Nepal and Bhutan also produces large cardamom. Sikkim contributes about 60% to the world's large cardamom production (total crop area ca 23,000 ha). In Sikkim, it is cultivated extensively in Dzongu and Kabi areas of the North District, Barapathing, Asam Lingjay and Aho in the East District, Rabong in the South District, and Yuksam, Sombaray and Pemayangtse in the West District (Krishna *et al.* 2002; Singh *et al.* 2005). The southern half of Sikkim has been predominantly used for large cardamom farming. About 1300 ha of reserved forest in Sikkim is still used for large cardamom cultivation on lease to farmers with no rights of felling the shade tree. The gross income from its cultivation in Sikkim had increased by more than three-fold to reach US$ 7.7 million in 1996 from its value 20 years earlier. Population growth and consequent fragmentation of farming-families have caused reduction in per capita agriculture land. Reduction in land-holding size forced farmers to cultivate cash crops such as ginger and orange that caused nutrient depletion to soil at a fast rate. The gross incomes of households and workers were found to be almost double in cardamom dominated system compared to traditional maize-potato dominated system (Singh *et al.* 2000; Sharma and Singh 2002). Cardamom-based agro-forestry practice keeps the tree cover intact enhancing the soil, water and nutrient conservation in fragile and steep slopes (Garg *et al.* 2003).

Out of 7,09,600 ha of the total geographical area only 87,194 ha (12.3%) of the land is available for cultivation, including current and other fallow land. Forest cover account for 41.9% of the total area of the state, while 25.4% is barren and uninhabited land which is found to be not fit for cultivation or for any other use.

The cropping pattern of a region is determined by factors such as elevation, topography, rainfall, temperature etc. A wide spectrum of climatic conditions in Sikkim ranging from subtropical to alpine zones are conducive for cultivation of a large number of crops. In general crops such as paddy and fruits are grown at the lower elevations while maize and potatoes dominate at the higher elevations. Cardamom is cultivated between warm to cool temperate zones. There has been a phenomenal change in the cropping pattern since 1975 after Sikkim's merger with the Indian Republic. The cereal-dominated subsistence agriculture has been slowly transformed to high-value cash crop-based commercial agriculture. There has been a shift in cropping pattern from cerealbased subsistence farming to the increased cultivation of pulses, oil seeds, fruits and vegetables where its demand and prices is becoming comparatively higher. Another trend has been interesting cultivation of cash crops such as ginger and mandarin orange in some areas. Many new cardamom plantations are found to be in terraced fields that have been used for cultivation of paddy and other crops earlier. State production of all the crops has increased, but average yield per unit area of mandarin orange and cardamom is in a downside. A large part of this erosion in yield may be accounted to citrus canker and stem-borer (in orange crops) and fungal disease, soil nutrient deficiency viral conditions (on the leaves and rhizome of cardamom).

Percentage increase of area under different crops over the increase in total area showed that the highest rise was recorded for cereals followed by large cardamom, oil seeds, vegetables, orange, pulses, ginger and potato. Percentage increase in the state production over total in the past 20 years clearly showed that crops like cereals, vegetables, ginger and potato performed very well. The percentage contribution of increase in large cardamom production was small, as it is a low-volume crop. Percentage contribution of gross income by each crop over total state income from all crops for the year 1995-96 clearly showed that the share of the large cardamom was next to the cereals. The cardamom cultivated area increased to the tune of 13.5%, while its contribution to the state production increased by just 0.82% from 1975 to 1996. However, its share in the state's gross income from all the crops was 16.58% in 1995-96 which is next to cereals' contribution of 31.14%.

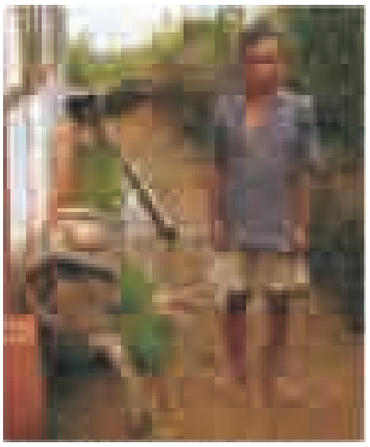
In 1975-76 cardamom contributed more than 80% to the state horticulture revenue which decreased to about 58% in 1985-86 and to about 38% in 1995-96. In recent years contribution of ginger has increased tremendously, but the net income from the cardamom stands out to be much higher. Two sites namely (a) cardamom dominated system and (b) maize-potato dominated system were selected (Sharma *et al.* 2002a and 2002b). Gross income from different livelihood options from these systems were compared and results showed that the household income and per person per day income were almost double in cardamom than in maize-potato dominated system. The income from large cardamom has been substantially higher compared to other livelihood options from both the systems.

Anthropogenic interventions

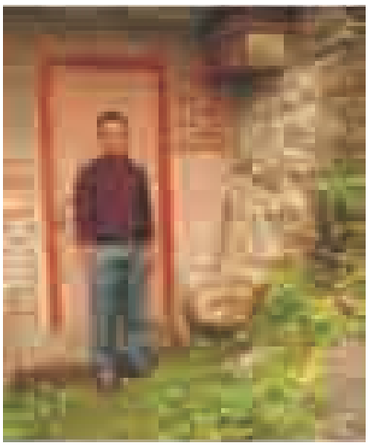
Earlier to the year 2002 the state agriculture saw a great boom in use of insecticides/ pesticides, etc. to counter the drop in crop yield but after it was declared as an “Organic State” all types of usage of chemical additives have been clamped down. The excessive use of pesticides and fungicides have rather a telling effect on the bee population. However, it is not known to what extent the ban on pesticide use has benefited the bee population in the region but a certain possibility of positive responses can not be ruled out. This is another aspect of man-made intervention versus the pollinating agents which duly needs a thorough investigation for understanding the relationship between the two. The hills of Sikkim practice multi-cropping system and as a rule of thumb 4 to 5 different crops constitute the general crop cover at any time of the year. Under such a situation the pollinators at large has an ample choice of visiting the flowers and during this time any particular “favoured” species may receive the greatest visit culminating in a greater chances of pollination and thus enhancing the crop yield of that particular crop. This fact, in general, may be applied to boost the crop yield through pollinators over different floral spectrum. However, it is yet to be seen how much the intercropping is influenced by the pollinators themselves or vice-versa, has made this situation a subject of scientific inquiry.

In essence, the pollinator-agriculture phase requires some subtle measures of location-specific researches. By far the subject has been ignored unintentionally for quite a long time but considering the very large population of pollinators in the region appropriate interests and research now seems obligatory. A regional framework is felt necessary at present to

Plate 1: Traditional bee-keeping in villages of Sikkim



Mamley, South Sikkim



Jaubari, South Sikkim

Cham Gaon, South Sikkim

Pabong, South Sikkim

Terikhola, South Sikkim

coordinate establishment of bee-population registry, defuse prevailing constraints and imparting share-basis knowledge for community empowerment as well balancing the nature's equation.

Pollinator aspect in Sikkim

The state of Sikkim with its rich flora and bee fauna has vast potential for development of apiculture. Moderate climate, evergreen vegetation and horticulture development makes the state suitable for intensive development in

beekeeping and also makes it a model which will highlight its organic status essential for the success of horticultural program in regard to its pollination potential. The hills and valleys of Sikkim are inhabited by populations of different honey-bee species of economic importance. Traditional beekeeping has been in practice in this region in log hives (gums), which provide semi-natural conditions to the bees (Photo plate 1).

Pollen-mediated gene flow in plants is affected by abiotic agents (wind, rain, etc) and biotic agents (bees, butterflies and moths, beetles, bats, birds, etc). These might have been functional over the centuries to maintain a good ecosystem in the Himalayan range. Pollinators of the region are ecologically well adapted and are associated with economic consequences but these are all undervalued. A wide range of resources including agricultural resource could be the result of good survival of pollinators in the region.

In the Himalaya, native species of bee namely, *Apis cerana* subsp. *cerana, A. cerana* subsp. *himalayana, A. dorsata, and A. laboriosa,* are common. Among them *Apis cerana* subsp. *cerana* are larger in size, more productive in terms of honey and less prone to negative traits such as frequent swarming and absconding found elsewhere recently. *Apis mellifera*, a native of Europe was introduced to promote bee-keeping in the Himalayan region in the past. A large number of flowering plants require honeybees and assorted pollinators for cross-pollination to ensure a good crop. The fruit-eating bats were also observed to pollinate some important plants in the Himalayan region but thorough study is still lacking.

From the total of about 1,400 types of butterflies recorded from the Indian subcontinent almost 50% of them are found in Sikkim (Haribal, 1992). In fact the following species have been so far recorded only from Sikkim – *Lethe trisigmata, Lethe adkinsoni* etc., and that too from high altitudes of Lachen and Lachung Valleys.

Flower peckers play an important role in the pollination of rhododendron species in the area. The birds are more generalized feeder and contributes significantly as a supplementary pollinator of many of the rhododendron species in the area excepting, some toxic nectar-yielding rhododendron species, which might be poisonous to it.

Insects appear to play a minor and uncertain role in the pollination of prevalent crops in Sikkim Himalaya. Exploding flower buds in the rhododendron and orchids promote an interesting relationship between the pollinator and the flower. Insect-pollinated flowers are characterized by their conspicuousness, distinct odor and presence of nectar with sticky large pollen. A diversity of insect species visit flowers and pollinate them, including bees, wasps, butterflies, moths, beetles, flies, etc.

Pollination has been considered as essential for survival of the plant species as well as existence of mankind. It is basically a mechanical transfer of pollens from anther to stigma in or between the flower. Honeybees are efficient pollinators of many cultivated and wild plants because of the following characteristics. (i) its body parts are specially modified to pick up more pollen grains, (ii) enhancement of flower fidelity and constancy, (iii) its potentiality for long working hours, (iv) maintainability of high population when and wherever needed, and (v) adaptability to different climates and niches. Many trees, shrubs and smaller plants benefit from the activity of bees in their fruit/seed setting. The important ones among these are apple, mandarin, pear, plum, peach, strawberry, melon, sunflower, etc. Apart from the birds, bats, and insects which are mainly associated with pollination in wild conditions the hymenoptera (bees) and lepidoptera (butterflies) have been found to constitute the major players in pollinating the farm crops in the region. Of the two, it is the various species of hymenoptera that are largely responsible for pollination of crops and these may be classified into the domesticated ones (*Apis mellifera*) and the wild species. There are instances where the wild species of *Apis* are successfully domesticated by many bee-keepers in the Sikkim.

Several biotic zones in Sikkim are the habitats of over 4,000 species of flowering plants including some important agricultural crops namely, large cardamom, mandarin, orange, maize, rice and tea. Sikkim contributes about 53% of world's production of large cardamom. Although this crop is capable of self-pollination, it is still observed that pollinators play a vital role in its alternative cross-pollination too. Since the state is having agricultural homogeneity and has also a biodiversity hot-spot bearing it stands a better chance in restoring a good genetic diversity as far as plants are concerned.

Bees, butterflies, flies, bats, beetles and rodents are some important pollinator elements and mediator of gene flow. These might have been functional over the centuries to maintain a good ecosystem in the Sikkim Himalayan ecozones. Pollinators of the region are ecologically well adapted and are associated with economic consequences however, all are undervalued, range of resources including agricultural resource could bring in a better survival scenario for pollinators in these hills.

At present, no other pollinator farming practices prevail in Sikkim except the few small-scale traditional apiary culture in some warmer areas e.g., Rangpo (East district), Central Pendam (East district) and Namchi (South district) which are either for commercial purpose or for use in the household. In essence, the pollinator-agriculture phase requires some subtle measures of location-specific researches. By far the subject has been ignored unintentionally for quite a long time but considering the very large population of pollinators in the region appropriate interests and research now seems obligatory. Pollen-mediated gene flow in plants is effected by abiotic agents, such as wind, and a number of biotic agents, of which the single most important pollinator group worldwide is that of bees. The production of fruits, seeds and more individuals of rare and endangered species depend directly on these agents in the majority of plant.

Endowed with a remarkable vegetation bounty the region may be considered as a haven for pollinators too which come in varied shape, size and descriptions. Sikkim Himalaya is a place around with cash crops of horticultural type (cardamom, mandarin oranges, ginger, tea, etc.). The adjoining Darjeeling hills and the Dooars vast tracts of land are covered by tea plantations. Under such a situation not only the pollinators thrive in number and varieties but it also exerts a commendable force over floral pollination eventually enhancing crop yield as well as bringing about genetic permutations in the crops.

Apart from the avifaunal elements (birds/bats) and insects which are mainly associated with pollination in wild conditions the hymenoptera (bees) and lepidoptera (butterflies) have been found to constitute the major players in pollinating the farm crops in the region. Out of the last two, it is the various species of bees that are largely responsible for pollination of crops and these may be classified into the domesticated ones (*Apis mellifera*) and the wild bee species.

Bee-keeping for generating additional income in the rural areas of Sikkim is an age-old practice. The lower and mid-hills, especially the mid-hills, are found to be favourable sites for bee-keeping activity. It is rather obvious that this practice goes in tandem with agricultural practice along the land gradient i.e., the more varieties of crop grown more hives are introduced. At the higher heights the agriculture translates into pastoralism and the bees are also absent. Though, a relationship between agriculture and the bees as pollinator is an established idea, how much the bees contribute to the productivity of a crop is yet to pass muster unless extensive research is done.

The Mamlay watershed in the South district of Sikkim has been identified as sites for visits/surveys study as it presents a good profile of altitude, ethno-culture and land use. The Mamlay watershed covering an area of 3,002 ha comprises varied land-uses such as, forests, agro-forestry, agriculture, settlement and wasteland, etc. The watershed comprises of 9 blocks (Mamlay, Kamrang, Jaubari, Singhithang, Pabong, Pakzer, Chemchey, Tingrithang and Damthang) and has special features to cover a wide range of agricultural practices and forest types in a gradient of altitude between 300-2,500 m. The main occupation of the people of this watershed is agriculture. The diverse vegetation of Sikkim provides ample opportunity to benefit beekeeping (Table 1 and 2).

Status, habitats and interactions of pollinators, reasons for pollinator decline

Sikkim Himalaya is also a place where cash crops of horticultural type abound (cardamom, mandarin oranges, ginger, etc.) and the adjoining Darjeeling hills and the Dooars (Terai foothills) are covered to a large extent by tea plantations (Sinu and Shivanna, 2007). Under such a situation not only the pollinators thrive in number and varieties but is also exerts a commendable force over floral pollination eventually enhancing crop yield as well as bring about genetic permutations in the crops (Bawa, 1990).

Although many different types of pollinating agents are found the best known ones belong to the groups of hymenoptera (bees and wasps) and to a lesser extent the lepidotera (butterflies and moths). The bees in the region are mainly the husbandeered colonies of *Apis indica*, though often species of *Apis mellifera* and the wild species *A. floriea* (locally known as *Kathyauree*) are found domesticated. At some places the *Putka* (*Trigona* sp., a smaller version of local bee race) are also observed in husbandeered form. In the wild some 5-6 species of bees are also noted but these are not properly studied. As a matter of fact the bees are so far the most neglected aspect of scientific inquiry in the region. The bees of the region are mostly confined to the temperate belt of 300-1000 m. Nevertheless, often these are found way above or below this limit, under husbandeered condition and less so in the wild state. In contrast, the butterfly community comprising 700 species has been studied to quite an extent. The lower valleys situated between 900-1800 m are the most favoured sites for the lepidopts and its roll as pollinators.

The region also has a remarkable number of avian members as well as arachnids – the elements which are considered the arch enemies to bees and especially to the butterflies. To a lesser extent the lizards and geckos also add to the list. However, the prime enemies to these pollinators still remain the human race. In the last quarter of the earlier century the rapid strides in developmental work and escalating population figure contributed much in disturbing the habitats of the wild pollinators and sometimes wiping out entire wild bee colonies. The use of chemical pesticides and insecticides in farm lands limited the size of bee colony and a number of bee-hives (Mattu and Mattu, 2003). Especially, in the case of the butterflies reduction in number and also in species has been recorded by Haribal (1992). Actual fallout of the above human interferences in checking/destroying pollinators has not been measured but the effect is obvious. Lately, after Sikkim was formally declared as an "Organic State" the use of chemical agents to various applications was thwarted. The effectiveness of this pioneering effort is yet to be gauged, however, no one can deny the relief vis-à-vis the ecosystem safety after the ban. The direct as well as residual effect of pesticidal use towards the health and survival of pollinators has been taken care of in the region.

The enabling environment

For the region, support programmes for enriching the pollinator sustainability aspect are sparse in number and under performance in effectiveness. The reasons of this situation lie both ways – the provider and the recipient – as well as the mechanisms in-between. As far as research and extension is concerned there is a big gap in the field of agriculture/horticulture research, taxonomical research or ecological research. This is another way of telling that not a single literature can be found on the hymenopterans of the region, and this falls true for the coleopterans, dipterans and the lepidopts (butterflies have been studied, but moths are yet to be documented). No one is surer than the other as to what may be the distribution of a any particular beetle in the region. On this basis of reckoning the ecological information over pollinator niche, amplitude and fidelity falls flat. In short, the research aspect on the pollinators of the region is still waiting to be unveiled and considering the pressure on natural resources the world over it better be soon rather than never.

Conservation of pollinators is another sphere of concern in the region in terms of natural resource management. For example, the wild *putka* honey bee may be enlisted under conservation law as restricted article but if it brings Rs. 800 per litre (the prevailing rate) there is enough incentive to go for it – the consequences do not matter much for the prospective collector. Thus, the "Seek-find-destroy" method for honey collection from the wild is not in vogue in the region as is elsewhere, nevertheless a wild beehive number is getting lesser every passing year.. The beehive is first smoked from below to disperse the wild bees and after that a man climbs to procure it or a long bamboo staff is brought to use to bring it down. In any case, the men involved know which bees produce honey, and which do not, and also to what measure. The knowledge is traditional and rich but applied towards a base purpose. So far, the stingless bees, viz., *Putka*, *Kathyauree*, and for that matter other wild variants have suffered quite a lot and before conservation finds a new meaning in the region still more colonies will continue establishing itself on the cliffs, to be pulled down one more time.

On the marketing front the bees (domesticated as well as wild species) stand out alone in the pollinator sector, due to its ability to produce honey in an accessible manner. Regular honey finds easy passage in the local market where the demand has always been higher than the supply. However, in the last few years the consumers have become wary of

taking raw honey because of the “harmful effects” of unprocessed honey. Though this has a hearsay basis but still the honey market is the ultimate loser. In the meantime private sector business houses entered into the foray with its processed brand of honey in sealed bottles. A processing unit is dearly wanting for the region to save the local honey from the onslaught of well-heeled players in the honey market.

Current knowledge on and capacity of pollinators

The farmers know that fruits or seeds come out of flowers but normally has no idea about pollinators or even pollination. An inconsistency to this is found in the school-educated mass that knows more about pollination as a process but has least to do with farmland, crops or crop yields. At the present, scientific workers in the region have not put their best expertise in this line of study and therefore no such literature exists on the subject. However, for crop biology, several workers have done excellent job however small, in providing catalogues, books and other descriptions related to pollinator of the region.

Apart from hybridization the role of a plant breeder also revolves around the pollen, its transfer and acquiescence in the recipient ovary. It is, therefore, obligate for him to study the pollinator too which in turn calls for a fair amount of knowledge on the members of the large Order Insecta. In fact, a plant breeder is a plant breeder-entomologist rolled into one and in the current situation there is no plant breeder who has done significant work on the pollinators of this region. In one's own individual way the breeder has set his focus on F1 and subsequent generation progeny of experimental plant and the entomologist does not look further that the insect that comes under the microscopic field. Although Sikkim Himalaya has a wealth of workers in the field of botany this void in insect studies is palpably visible. A university, several colleges, a botanical garden, many scientific organizations and various NGOs form the scientific fraternity in the region but so far the knowledge over pollinators of the region has yet to get a good start. In a nutshell the database bank on aspect of the region is almost non-existent.

Existing databases and other information networks

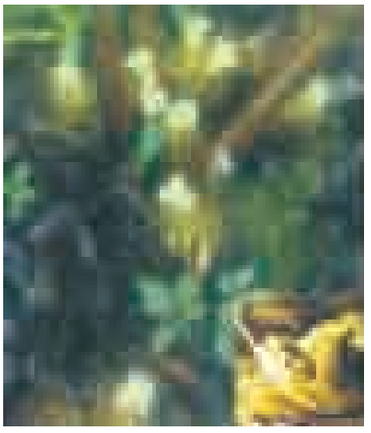
Databases on pollinators of the region may be amiss but knowledge on the various aspects of pollinating agents is still a living proposition mainly in the rural situation. As a rule, almost every homestead at the temperate location keeps a bee colony, usually two, and sometimes three or more hives are found. How much this arrangement contributes to the overall pollinator sector is not known but most of the persons know about the bees to an extent and a few have acquired great depth of knowledge in the process through decade of observation. There are farmers who can exactly locate the source of honey from the flavour it imparts. Expertise is found on the few who know how to domesticate wild strain of bees. More in-depth dialogue would reveal some more on the knowledge residing in the bee-keepers and with proper handling it can be tapped to a good measure. This data may be overlapped on pollinator and pollination information to obtain knowledge on functioning of the system.

In this milieu of dedicated apiculturists a group also stands out apart who possess a veritable mine of information on the pollinators i.e., the trainers (apiculture specialists). Though these people have a one-time job maybe earmarked for a single year they are more or less related *de rigueur* to the apiary system. It was also found that the trainer is always one-step ahead of his students from the start and the gap widens with every passing years. With exposure to a large audience every time during his assignments he gathers a wealth of information from people far and wide while working under different physical and socio-economical surroundings. Though not exactly conforming to a network every training session may effectively be converted and linked into a community networking system if properly articulated with work plans and management details. In a practical sense this may also work as a viable alternative to convey information on farmer-to-farmer basis, farmer-to-expert basis and between diverse farming networks. In due time the smaller networking units may collate to a federation representing a regional apiary community and database archive. Records show that bee-keeping cooperative societies were operational earlier too but due to certain reasons these folded up in later years.

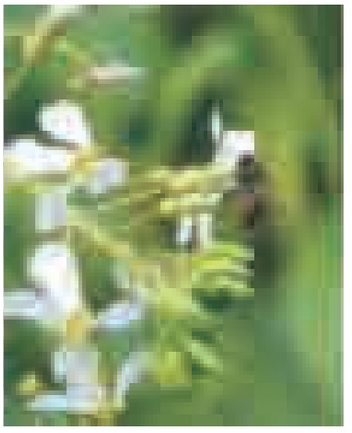
Database work, in fact, comes at an early date than research, development or extension implemented. Therefore, before any action could be taken up or a plan is to be executed the *primus inter pares* will always be the amount and quality of ground truth information. In the Sikkim Himalayan context this widely scattered and sometimes poorly understood datasets has to be pooled in first to bring light over the subject at hand.

Local management practices and traditional knowledge

The pollination problem is a relatively new one but owing to its gravity and deep-rooted consequences to food security needs due attention at this early stage. However, in the region nobody has the slightest perception that the honeybees contribute to the yield of crops growing in the nearby fields. It so happened because no one cared to delve deeper into the pollination-crop yield equation. In any case the traditional apiary system or rather the knowledge on bees and how to get honey out of it, drew up a basic value in rural condition and has been instrumental in conserving apiculture in favour of pollination and food security.



Pollination in Large cardamom



Pollination in Radish

Pollination in Mustard

A log beehive of *Trigona* sp. (Putka). Insect: the entrance which is lined by wax is a typical identity of this stingless bee

With the advent of Khadi Mission and setting up of KVICs (Khadi & Villages Industries Centres) all over the country the apiary horizon broadened up. Even here the Sikkim Himalayan region experienced a belated start, it being a sovereign kingdom under the Maharaja (Chhogyal Paljor Namgyal) till 1975. The merging of Sikkim within the Indian Republic in 1975 and after it ushered in all the plans/projects and missions of national concern all over the hills. KVICs leaned on gas to accelerate apiculture at different parts of the state, scientific apiary trainings were organized, supports were provided, follow-ups were constantly made and products pushed into market channels. In a nutshell, these constitute the pollinator aspect brought about by apiary in the region but still the aspect of pollinator-crop yield relationship remained under darkness, its conservation not realized and sustainable ecosystem approach has always taken a back seat.

As far as the effectiveness of pollinators to sustainable agriculture is concerned the subject has lots of darker sides in store. For the region, most of the crops covering the lion's share of arable land fall under anemophilous group in terms of pollination. Apart from this wind-pollinated crop group a major part constitutes the agroforestry types, viz., cardamom (*Amomum subulatum*) and mandarin oranges (*Citrus reticulata*). As the flowers of these crops open up in an acropetal order the pollination process is a long drawn out one, sometimes the flowering stretching to 30-40 days. Throughout this period what the pollinators do, how and when, for these crops still remain under fog. The other horticultural crop, mainly falling under “vegetable” group, have no use of pollinating agents as because the plant body (cabbage, radish, turnip, cress, leek, etc.) are marketed before seed setting therefore the actions of pollinators become seeds or seed setting is immaterial. However, for cross-pollination and vigour build-up in the subsequent generations pollination still remains the only answer and pollinators can always enter at this point of debate. Additionally, in Sikkim a large number of temperate fruit trees (apple, peach, plum, pear, guava, etc.) depend on pollinators for bearing fruits.

The average farmers do not know the pollination-fruit setting mechanism and treat the pollinators as insects which are just happy to forage for nectars. At a general level, primitive cultural and processing practices are still found only in the apiary scenario. The widely accepted 1 colony : 1 acre (or 2 colonies : 1 ha) plan is never followed because the farmer is not inclined on increasing crop yield, rather more concerned to the health and upkeep of bees. Sustainability is yet to get a meaning around the rural commune.

CONCLUSIONS

It is now known that the pollinator population is dwindling in the region along with the lowering of crop productivity. However, this decrease in crop production may not be the sole reason that the pollinators are getting fewer in number in the region. There are a number of other factors involved which can be responsible for this state of affairs, viz., land holding shrinkage and fragmentation, increased incidence of disease owing to the ban on pesticides/insecticides, soil nutrient status, etc. and other climatic variables for a particular period of time which affects the crop production. This may be understood from the fall in ginger and potato productivity in the state when these crops have nothing to do with pollinators (i.e., propagated through rhizomes and tubers).

The decrease in hive numbers and wild colonies, under the husbandeered and non-husbandeered forms, is being seen at present as the fallout of chemical use in agriculture which was a common practice in the past and before the state being declared as a pesticide-free zone. Recent observation on sighting of newer colonies of the wild forms of native bees shows that it is in the rejuvenation phase of its survival cycle. However, the increase of hives seen in the husbandeered form at the present cannot be interrelated with the increased number of colonies in the wild as because this depends upon the human skill and application. Apart from these the forests fires also inflict considerable damage to the native bees and other pollinators.

The wild species of stingless bees, viz., *Apis floriea* (*Kathyauree*) and *Trigona* sp. (*Putka*) needs extensive conservation attention in the region to save it from extinction. As these species are normally found in the wild and has lesser chances of pollinating the crop plants they are important for the woodland plants. Their service will be perceived as more important if they pollinate a few and selected plants in the forest apart from the many tree species.

Extensive studies on the pollinators, from the pollinator point-of-view as well as from the pollinated plant aspect, are to be initiated to understand the nature and dynamics of the entire system. We, so far, do not know where to make a start but a beginning maybe made from the endangered species towards the lesser threatened ones. Similarly, it was observed that the bats and other nocturnal birds/mammals have been less understood in terms of its pollination behavior of native plants.

Considering the epic importance of pollinators and especially the bees under the concept "No bees – No lives (on earth)" it is high time that adequate efforts should be made for its study and more importantly, for its conservation. What Einstein noted years ago, the time now has come to think seriously over it - "If the bee disappeared off the surface of the globe then man would only have four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man."

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Table 1: Plants at Mamlay Watershed, South Sikkim, recommended for beekeeping

S.No.	Scientific name	Local name	Use
1	*Amomum subulatum*	Thulo alainchi	Spice
2	*Bassia butyracea*	Chiuree	Fodder
3	*Bombax malabaricum*	Simal	Cotton substitute
4	*Brassica alba*	Tori	Vegetable
5	*Brassica campestris*	Rayo	Vegetable
6	*Capsicum* sp	Khorsani	Vegetable
7	*Citrus reticulata*	Suntala	Fruit
8	*Cucurbita moschata*	Pharsi	Vegetable
9	*Cymbidium sp*	Sunakhari	Ornamental
10	*Juglans regia*	Okhar	Fruit, wood
11	*Lycopersicum esculentum*	Tamatar	Vegetable
12	*Magnolia campbelli*	Chanp	Wood
13	*Oroxylum indicum*	Totala	Medicine
14	*Passiflora indica*	Garendal	Fruit
15	*Phaseolus aureus*	Kalo dal	Pulse
16	*Phaseolus cummunis*	Simi	Pulse, vegetable
17	*Pisum sativum*	Matar	Vegetable
18	*Prunus cerasoides*	Payiun	Ornamental, fuel
19	*Prunus nepalensis*	Arupatay	Ornamental
20	*Prunus persica*	Aaroo	Fruit
21	*Psidium guajava*	Ambak	Fruit
22	*Pyrus pashia*	Naspati	Fruit
23	*Fagopyrum esculentum*	Phapar	Cereal
24	*Rubus ellipticus*	Aiseloo	Fruit
25	*Schima wallichi*	Chilauney	Fodder
26	*Sechium edule*	Ishkush	Vegetable
27	*Sesamum indicum*	Tori	Vegetable, oil
28	*Solanum melongena*	Baigun	Vegetable
29	*Vicia faba*	Cheptay simi	Vegetable
30	*Vigna radiata*	Masyam	Pulse

Table 2: Species mostly benefited by pollinators

Scientific name	Common name	Flowering period
Edible fruits:		
Allium wallichii	Jungali piyaj	Aug-Oct
Bassia butyracea	Chiuree	Feb-March
Bauhinia variegata	Koiralo	Nov-Feb
Castanopsis hystrix	Patlay katus	April-May
Castanopsis tribuloides	Musray katus	April-May
Cinnamomum impressinervium	Sissi	May-June
Citrullus colocathus	Indreni	April-May
Elaeocarpus lanceafolius	Bhadrasay	May-Jun
Evodia fraxinifolia	Khanakpa	May-June
Garcinia cowa	Kaphal	May-June
Girardinia palmata	Bhangre sisnu	Aug-Sep
Juglans regia	Okhar	Apr-May
Laportia terminalis	Patlay sisnu	Aug-Sep
Machilus edulis	Lapche kawla	May-June
Machilus odoratissima	Lalikaulo	May-June
Prunus nepalensis	Arupatay	May-June
Pyrularia edulis	Amphi	May-June
Pyrus indica	Mehel	April-May
Quercus lineata	Phalant	April-May
Quercus pachyphylla	Sunguray katus	April-May
Rhus semialata	Bhakimlo	June-August
Rubus ellipticus	Aiseloo	Jan-Feb
Rubus niveus	Kalo aiseloo	Jan-Feb
Spondias axillaris	Lapsi	May-June
Pyrus cummunis	Naspati	March-April
Prunus persica	Aaroo	March-April
Passiflora indica	Garendal	April-May
Amomum subulatum	Large Cardamom	April
Citrus reticulata	Suntala	April
Medicinal Plants:		
Aconitum heterophyllum	Bikhma	Sep-Oct
Artemisia vulgaris	Titepati	Sep-Oct
Astilbe rivularis	Buro okhati	July-Sep
Bergenia ciliata	Pakhanbet	June-Sep
Dichroa febrifuga	Basak	Aug-Sep
Drymaria cordata	Abijalo	Sep-Oct and April-May
Eupatorium adenophorum	Banmara, Kalijhar	June-Sep
Heracleum wallichi	Chimphing	Aug-Sep
Kaempferia rotunda	Bhuin champa	Aug-Oct
Picrorhiza kurrooa	Kutki	Year-round
Piper longum	Pipla	Year-round
Rubia cordifolia	Majito	July-Sep
Rumex nepalensis	Halhalay	April-May
Swertia chirata	Chiraito	July

Scientific name	Common name	Flowering period
Common Horticultural Crops:		
Phaseolus aureus	Kalo dal	Sep-Oct
Phaseolus mungo	Pahelo dal	Sep-Oct
Phaseolus aureus	Masyam dal	Aug-Sep
Phaseolus sp	Singtamay simi	April and Oct.
Prunus sp.	Painyu	Feb-March
Cucurbita moschata	Pharsee	May-June
Pisum sativum	Matar	Sep-Oct and Feb-March
Brassica gentia	Rayo saag	Nov-Dec
Raphanus sativa	Mula	Dec-Jan
Solanum tuberosum	Aloo	Dec-Jan and April-May
Solanum melongena	Baigoon	April-June
Brassica oleracea var. *capitata*	Bandakopi	Feb-March
Brassica oleracea var. *campestris*	Phulkopi	Feb-March
Capsicum sp.	Khorsani	April-June
Sechium edule	Ishkush	May-Agust
Solanum tuberosum	Aloo	
Zingiber officianale	Aduwa	
Agricultural Crops:		
Zea mays	Makai	May-Aug
Oryza sativa	Dhan	Sep-Oct
Triticum aestivum	Gahun	March-May and Jan-Feb
Fagopyrum esculentum	Phapar	Oct-Nov
Brassica campestris	Mustard	April-May

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