



Personal Protective Equipment for Beekeepers

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Guide: Prof. R. Sandesh

Acknowledgements

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And finally I would also like to thank all my classmates for their inputs, advices and tremendous help during the entire project.

What's Inside ?


HONEY

Chapter 1

Honey Bees

Honey Bees

a.Introduction

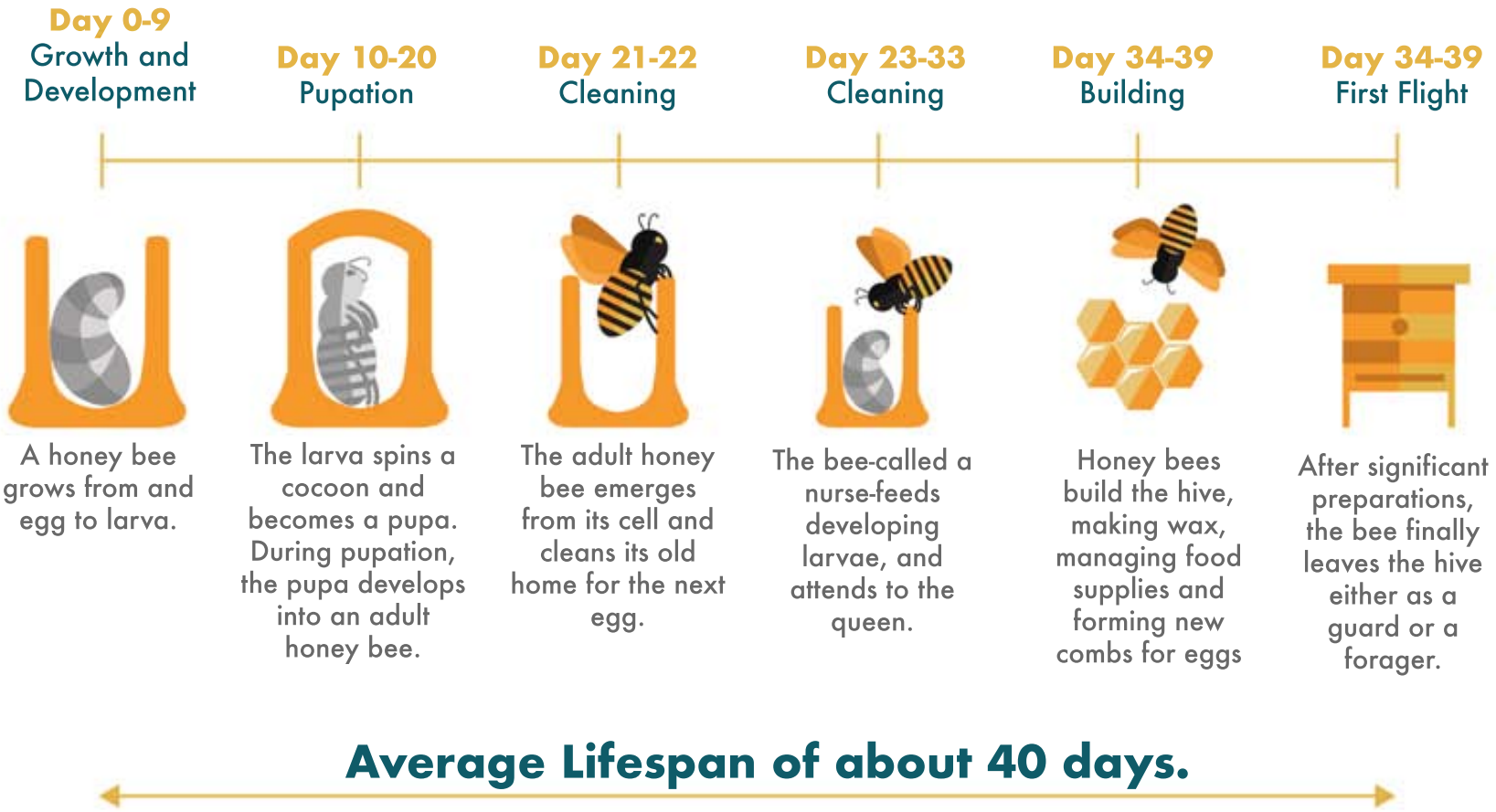
A honey bee is any bee member of the genus Apis, primarily distinguished by the production and storage of honey and the construction of perennial, colonial nests from wax.

Currently, only seven species of honey bee are recognized, with a total of 44 subspecies, though historically, from six to eleven species have been recognized. The best known honey bee is the Western honey bee which has been domesticated for honey production and crop pollination. Honey bees represent only a small fraction of the roughly 20,000 known species of bees. Some other types of related bees produce and store honey, including the stingless honey bees, but only members of the genus Apis are true honey bees. The study of bees including honey bees is known as melittology.

Ref: https://apicultural.wordpress.com/2013/03/06/types-of-honey-bee/

Honey Bees

a. Introduction



http://www.beesmatter.ca/wp-content/uploads/2016/03/Bees_Matter_Infographics

Honey Bees

b. Different types of honey bees found in india

1. **Apis dorsata**, the giant honey bee, is a honey bee of southern and south-eastern Asia. The subspecies with the largest individuals is the Himalayan cliff honey bee – Apis dorsata laboriosa – but typical Apis dorsata are around 17–20 millimetres long.

2. **Apis cerana indica** is a subspecies of honey bee. A. c. indica is one of the important pollinating agents for coconut palms; the other species are: Apis florea, Apis dorsata and Apis mellifera, Apis cerana.

3. The dwarf honey bee or red dwarf honey bee or **Apis florea**, is one of two species of small, wild honey bees of southern and south-east asia.

Ref: https://apicultural.wordpress.com/2013/03/06/types-of-honey-bee/

Honey Bees

b. Different types of honey bees found in india

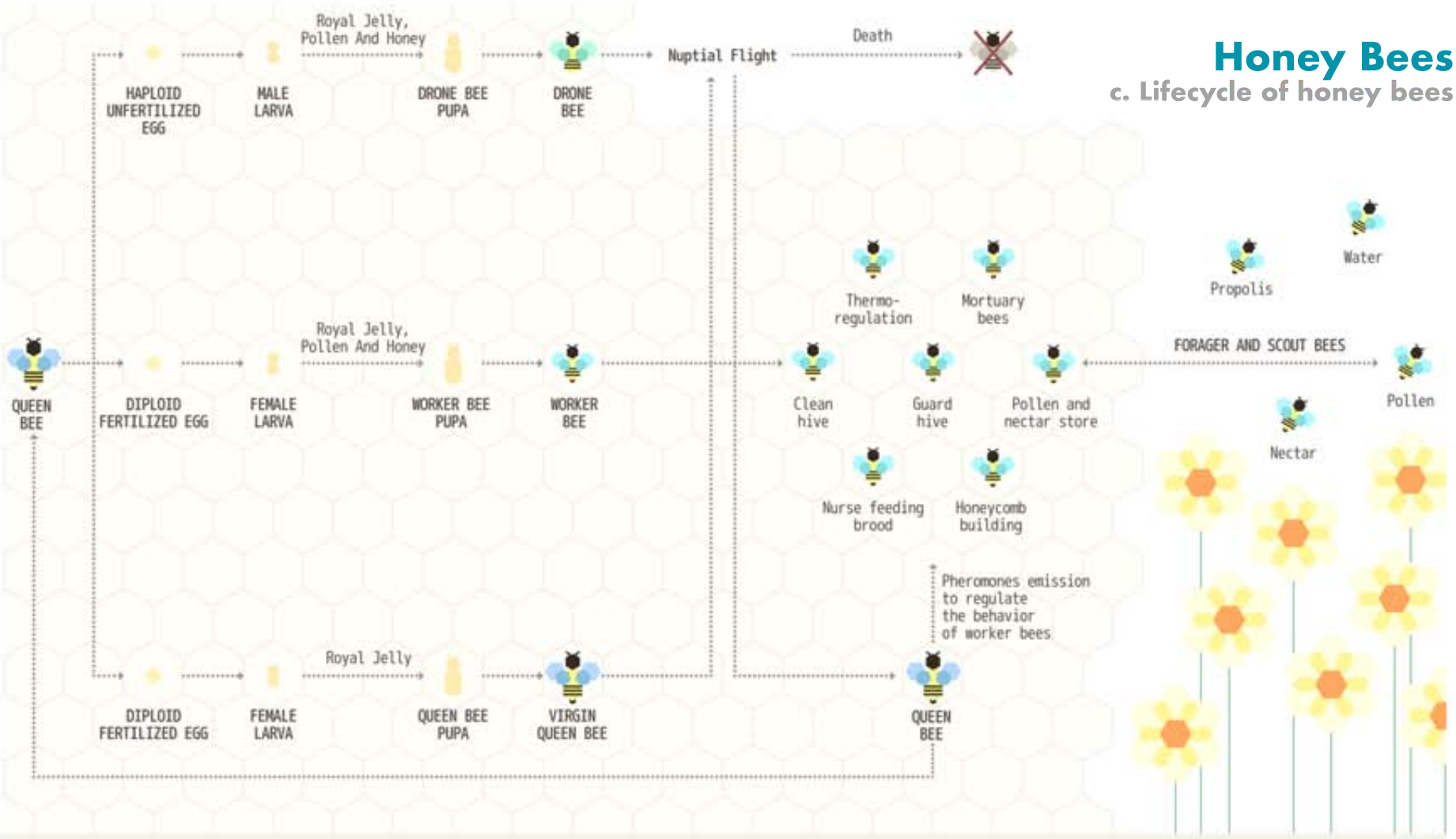
4. **Apis mellifera** or the western honey bee or European honey bee is the most common of the 7-12 species of honey bee worldwide.

5. **Meliponula ferruginea** or the dammer bee is very tiny with a vestigial sting and is different from the former three species in appearance and habits.

Ref: https://apicultural.wordpress.com/2013/03/06/types-of-honey-bee/

Honey Bees

c. Lifecycle of honey bees



DRONE BEE

Male haploid bee
(100-500 per hive)
Length 15-17 mm
Lives about 50 days
Fertile male bee
Mates the queen

WORKER BEE

Female diploid bee
(10.000-50.000)
Lenght 12-15 mm
Lives 6 weeks - 9 months
Builds and protects the hive, stores food and feeds the brood

QUEEN BEE

Female diploid bee
(1 per hive)
Lenght 18-22 mm
Lives 2-7 years
Only fertile female bee
Lays about 1.500 eggs per day and emits pheromones

BEESWAX

Worker bees of a certain age secrete beeswax from a series of glands on their abdomens. They use the wax to form the walls and caps of the comb.

POLLEN

Pollen is a powder produced by flowers. In the hive, pollen is added honey and bee secretions and stored in brood cells. This is called Bee Bread and provides proteins.

HONEY

Honey is the substance made when the nectar and sweet deposits from plants and trees are gathered, modified, and stored in the honeycomb by honey bees as a food source for the colony.

PROPOLIS

Propolis or bee glue is created from resins, balsams, and tree saps. Honey bees use propolis to seal cracks in the hive.

NECTAR

Nectar is a liquid high in sucrose, is produced in plant glands known as nectarie. It is an important energy resource for honey bees.

ROYAL JELLY

Royal Jelly is secreted from the glands in the hypopharynx of worker bees, and used in the nutrition of all larvae in the colony and adult queen bee.

Ref: https://en.wikipedia.org/wiki/Honey_bee#Sexes_and_castes

Honey Bees

d. Sexes and castes

A caste is a different form, morphologically or reproductively, within the same sex of a species. Honey bees have three castes: drones, workers, and queens. Drones are male, while workers and queens are female.

Drones

Males, or drones, are typically haploid, having only one set of chromosomes. They are produced by the queen if she chooses not to fertilize an egg; or by an unfertilized laying worker. They do not have a stinger.

Workers

Workers have two sets of chromosomes. They are produced from an egg that the queen has selectively fertilized from stored sperm. Workers typically develop in 21 days. A typical colony may contain as many as 60,000 worker bees.

Queens

Queen honey bees are created at the decision of the worker bees by feeding a larva only royal jelly throughout its development, rather than switching from royal jelly to a mixture of honey and pollen known as bee bread once the larva passes three days of age.

Ref: https://en.wikipedia.org/wiki/Honey_bee#Sexes_and_castes

Honey Bees

e. Beehive

A beehive is an enclosed structure in which some honey bee species of the subgenus Apis live and raise their young. Natural beehives are naturally occurring structures occupied by honeybee colonies, such as hollowed-out trees. The domesticated honeybees live in man-made beehives, often in an apiary.

The beehive's internal structure is a densely packed group of hexagonal cells made of beeswax, called a honeycomb. The bees use the cells to store food (honey and pollen) and to house the "brood".

Honey bees use caves, rock cavities and hollow trees as natural nesting sites. Members of other subgenera have exposed aerial combs. The nest is composed of multiple honeycombs, parallel to each other, with a relatively uniform bee space. It usually has a single entrance. Western honey bees prefer nest cavities approximately 45 litres in volume and avoid those smaller than 10 or larger than 100 litres.

Artificial beehives serve several purposes: production of honey, pollination of nearby crops, housing supply bees for apitherapy treatment, as safe housing for bees in an attempt to mitigate the effects of colony collapse disorder, and to keep bees as pets.

Ref: https://en.wikipedia.org/wiki/Beehive

Chapter 2

Beekeeping

Beekeeping

a. Introduction

Beekeeping is the maintenance of honey bee colonies, commonly in hives, by humans. A beekeeper (or apiarist) keeps bees in order to collect their honey and other products that the hive produces (including beeswax, propolis, pollen, and royal jelly), to pollinate crops, or to produce bees for sale to other beekeepers. A location where bees are kept is called an apiary or "bee yard".

Depictions of humans collecting honey from wild honey bees date to 15,000 years ago.

Traditional: A fixed comb hive is a hive in which the combs cannot be removed or manipulated for management or harvesting without permanently damaging the comb. Almost any hollow structure can be used for this purpose, such as a log gum, skep, wooden box, or a clay pot or tube.

Fixed comb hives are no longer in common use in industrialized countries, and are illegal in places that require movable combs to inspect for problems such as varroa and American foulbrood.

Beekeeping using fixed comb hives is an essential part of the livelihoods of many communities in poor countries.

The charity Bees for Development recognizes that local skills to manage bees in fixed comb hives are widespread in Africa, Asia, and South America. Fixed comb hive is not in use anymore

Ref: https://en.wikipedia.org/wiki/Beekeeping

Beekeeping

b. Modern beekeeping - types

Top bar hives have been widely adopted in Africa where they are used to keep tropical honeybee ecotypes. Their advantages include being light weight, adaptable, easy to harvest honey, and less stressful for the bees. Disadvantages include combs that are fragile and cannot usually be extracted and returned to the bees to be refilled and that they cannot easily be expanded for additional honey storage.

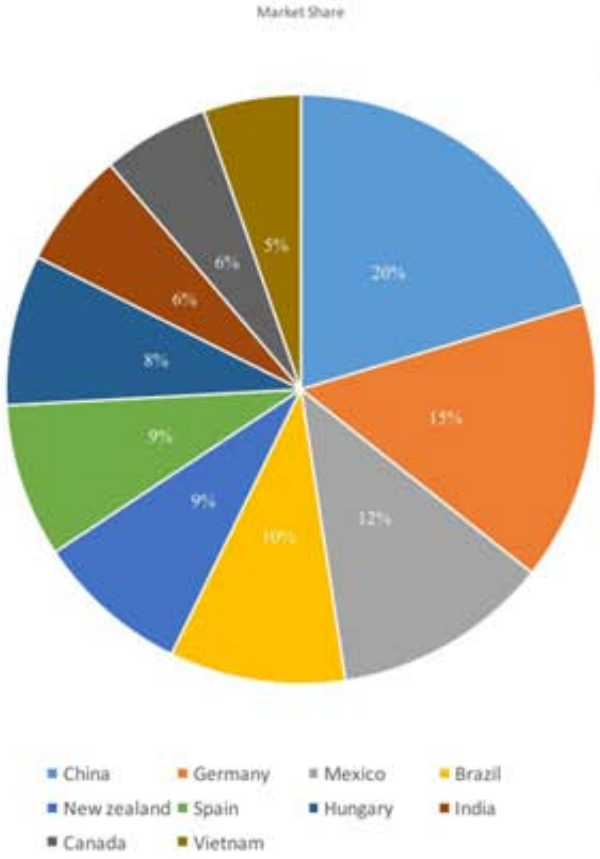
Horizontal Hive are widely used in Spain, France, Ukraine, Belarus, Africa, and parts of Russia. They are a step up from fixed comb and top bar hives because they have movable frames that can be extracted.

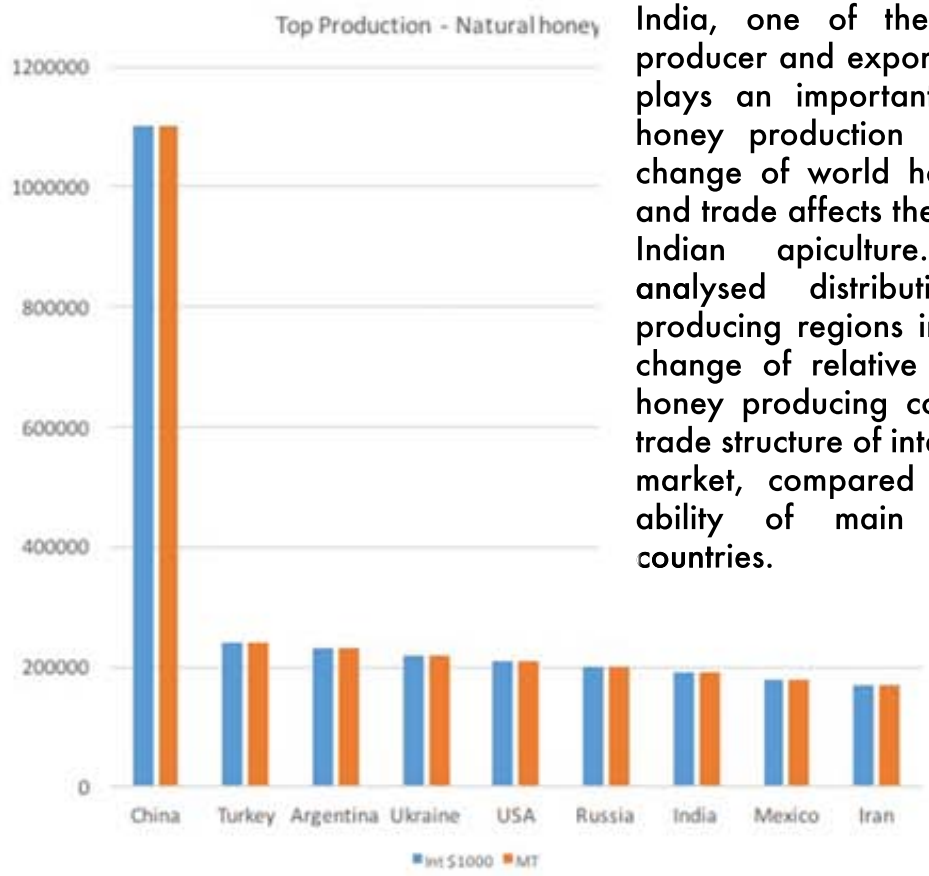
Vertical hive designs are based on the principle of bee space first described by Langstroth. The Langstroth hive is a descendant of Jan Dzierzon's Polish hive designs. This hive is a modern design that attempts to address many of the flaws and limitations of other movable frame hives.

Ref: https://en.wikipedia.org/wiki/Beekeeping#Modern_beekeepin

Beekeeping

c. Beekeeping industry in india



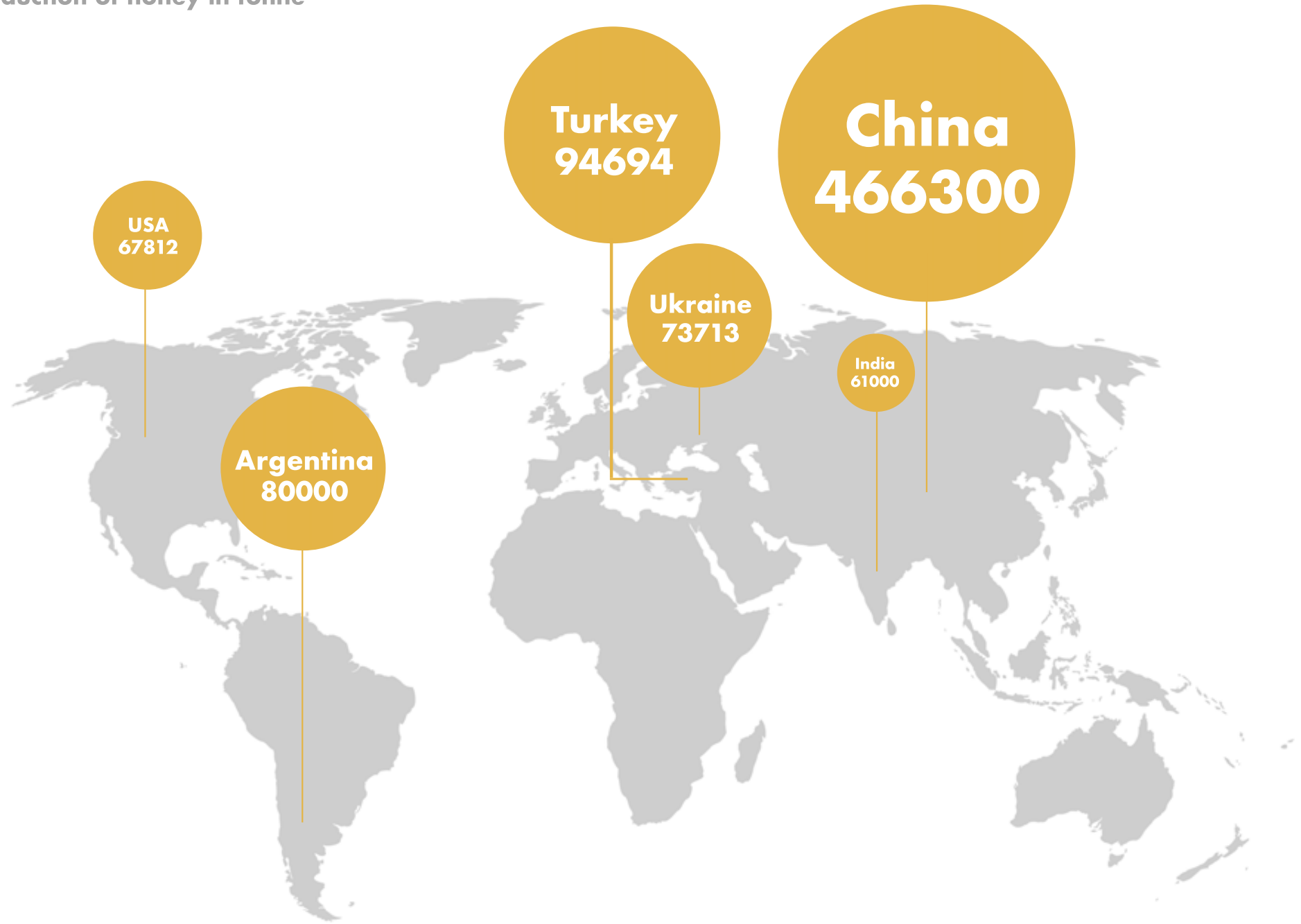


India, one of the largest honey producer and exporter in the world, plays an important role in world honey production and trade. The change of world honey production and trade affects the development of Indian apiculture. This paper analysed distribution of honey producing regions in the world, the change of relative status of major honey producing countries and the trade structure of international honey market, compared the competitive ability of main honey export countries.

Ref:http://www.impactjournals.us/download.php?fname=2-14-1406205494-16.%20Applied-Beekeeping%20industry%20in%20India%20Future%20potential-Tarunika%20Jain%20Agrawal.pdf.

Beekeeping

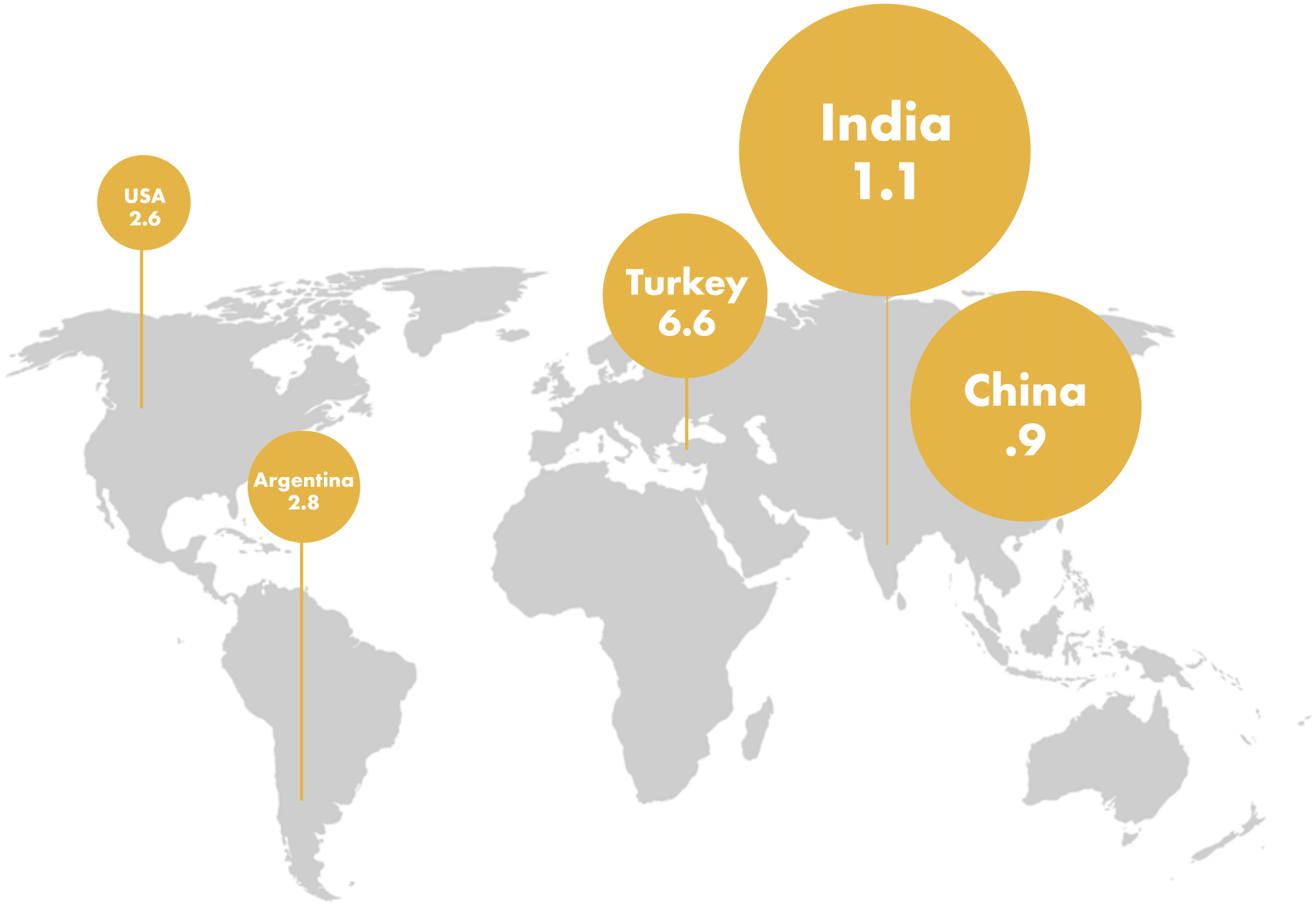
Production of honey in tonne



Ref: http://www.indiastat.com/table/agriculture/2/honeybeekeeping/17463/768669/data.aspx

Beekeeping

Number of beehives in million



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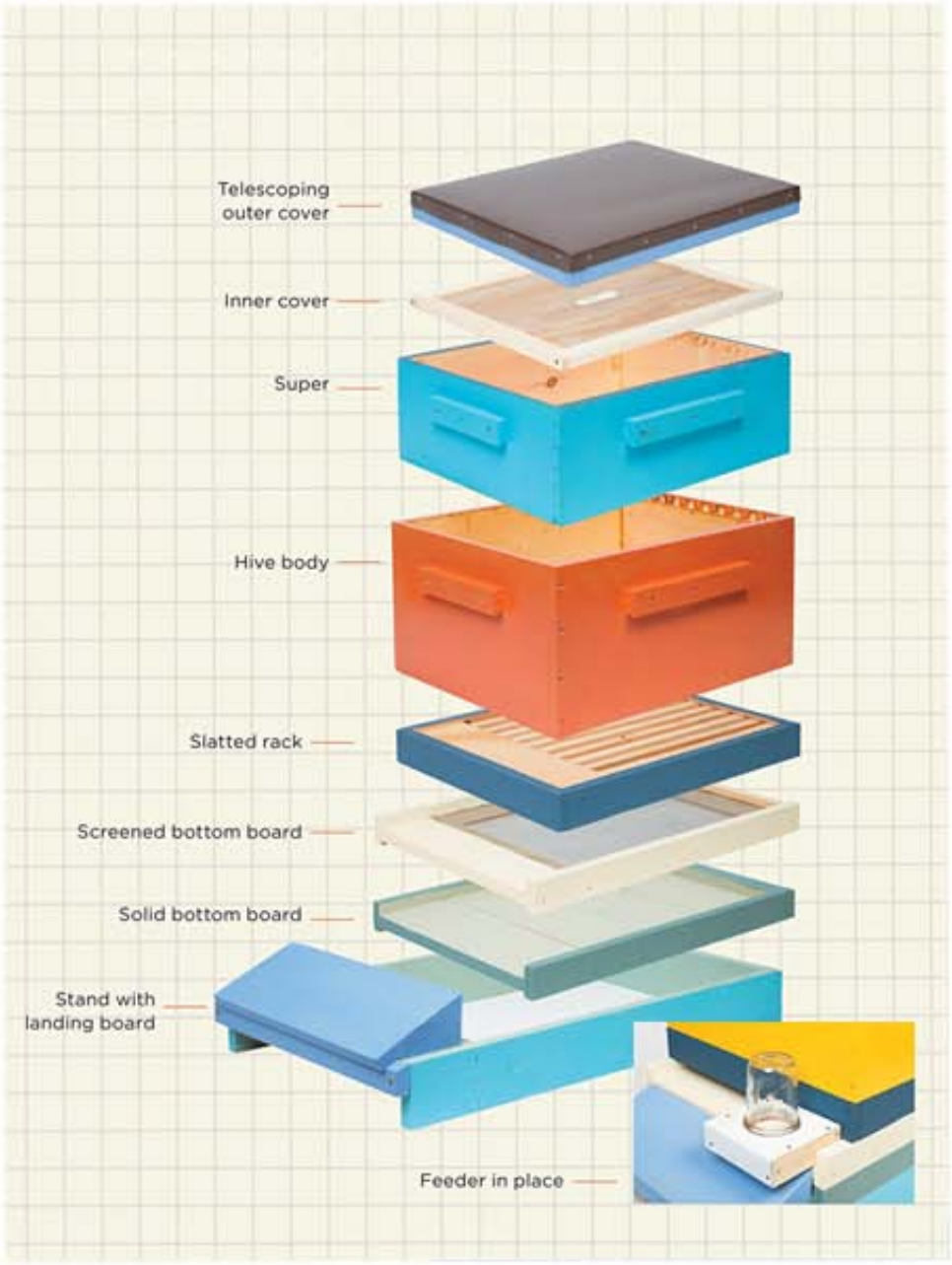
Beekeeping

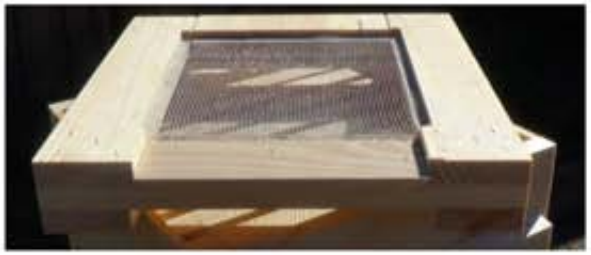
d. Beekeeping equipment



https://images-na.ssl-images-amazon.com/images/I/915jSvqsu4L.jpg

The hive stand is actually an optional piece of equipment, elevates the bottom board of the hive off the ground. In principle, this support reduces dampness in the hive, extends the life of the bottom board, and helps keep the front entrance free of grass and weeds. Hive stands may be concrete blocks, bricks, railroad ties, pallets, logs, or a commercially produced hive stand. A hive stand may support a single colony, two colonies, or a row of several colonies.

The bottom board serves as the floor of the colony and as a take- off and landing platform for foraging bees. Since the bottom board is open in the front, the colony should be tilted forward slightly to prevent rainwater from running into the hive. Bottom boards available from many bee supply dealers are reversible,providing either a 7/8 - or 3 /8 -inch opening in front.



The hive body is available in four common depths or heights. The full-depth hive body, 95/8 inches high, is most often used for brood rearing. These large units provide adequate space with minimum interruption for large solid brood areas. They also are suitable for honey supers.

The frame is the basic structural component inside the hive. In a man-made hive, the wooden or plastic beeswax comb is started from a sheet of beeswax or plastic foundation. After the workers have added wax to draw out the foundation, the drawn cells are used for storage of honey and pollen or used for brood rearing.

Ref: http://www.lehighvalleybeekeepers.org/Documents/BeekeepingBasics.pdf

Beekeeping

d. Beekeeping equipment

The queen excluder is for connecing the queen and her brood and to store pollen in the brood nest. It is an optional piece of equipment and is used by less than 50 percent of beekeepers.

The inner cover rests on top of the uppermost super and beneath the outer telescoping cover. It prevents the bees from gluing down the outer cover to the super with propolis and wax. It also provides an air space just under the outer cover for insulation.

Outer Covers flushes with the sides of the hive body and may or may not extend over the ends. In addition to being lightweight and easy to remove, these covers allow colonies to be stacked.

Ref: http://www.lehighvalleybeekeepers.org/Documents/BeekeepingBasics.pdf

A bee smoker and hive tool are essential for working bees. The smoker consists of a metal re pot and grate with bellows attached. The size of the smoker is a matter of individual preference. The 4 x 7inch size is probably the most widely used.

The hive tool is a metal bar essential for prying apart frames in a brood chamber or honey super, separating hive bodies, and scraping away wax and propolis. Holsters to hold hive tools are available, but many beekeepers prefer to hold the hive tool in the palm of their hand to keep it accessible and to keep their fingers free for lifting boxes and frames.

Ref: http://www.lehighvalleybeekeepers.org/Documents/BeekeepingBasics.pdf

Chapter 3

Personal Protective Equipment

Personal protective equipment

a. Introduction

Personal protective equipment refers to protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. Protective equipment may be worn for job-related occupational safety and health purposes, as well as for sports and other recreational activities. "Protective clothing" is applied to traditional categories of clothing, and "protective gear" applies to items such as pads, guards, shields, or masks, and others.

The purpose of personal protective equipment is to reduce employee exposure to hazards when engineering and administrative controls are not feasible or effective to reduce these risks to acceptable levels.

PPE has the serious limitation that it does not eliminate the hazard at source and may result in employees being exposed to the hazard if the equipment fails.

Any item of PPE imposes a barrier between the wearer/user and the working environment. This can create additional strains on the wearer; impair their ability to carry out their work and create significant levels of discomfort. Any of these can discourage wearers from using PPE correctly, therefore placing them at risk of injury, ill-health or, under extreme circumstances, death.

Ref: https://en.wikipedia.org/wiki/Personal_protective_equipment

Personal protective equipment

b. Types

Hazmat suits are worn for protection against hazardous materials, as well as dangerous chemicals and toxins. They are generally worn by people who work in environments that are dangerously contaminated, but are also worn by several law enforcement agencies such as the DEA, whenever necessary.

Firefighter suits are the most important equipment for a firefighter. Putting out blazing fires is perhaps one of the most dangerous jobs there it. Because of this, firefighters are equipped with a heavy duty protective suit, loaded with features to help keep them safe. It goes without saying that the main feature of a firefighter suit is its fire resistant material made of Kelvar and Nomex.

Wetsuits are worn by watersport enthusiast and career divers, wetsuits while seemingly simple, provide lots of protection. The neoprene material provides quality insulation allowing users to maintain their normal body temperature even in dangerously cold water conditions. The structure of the suit makes it durable and flexible making it easy to move around and swim in.

Beesuits are worn by the beekeepers. The face and neck are the most important areas to protect, so most beekeepers wear at least a veil. Defensive bees are attracted to the breath, and a sting on the face can lead to much more pain and swelling than a sting elsewhere, while a sting on a bare hand can usually be quickly removed by fingernail scrape to reduce the amount of venom

Ref: https://en.wikipedia.org/wiki/Personal_protective_equipment

The Ultra breeze uses ventilated fabrics that keeps the beekeepers protected and Cool. Made in the USA, the Ultra Breeze uses three layers of ventilated fabric to provide protection and to keep the user cool. The depth of the fabric layers prevents bee stings from reaching your skin, and the suit continues to protect you even if it gets wet. The ventilated fabrics also keeps the user cooler by allowing their body heat to escape. Traditional suits trap their body heat causing the temperature in the suit to rise. The risk of dehydration and heat stroke in the summer, especially for commercial beekeepers are high.

It is designed for comfort and ease of use. The construction of the suit allows the user to bend and reach comfortably. Genuine 5YKK Brass zippers, more durable than plastic, extend up the length of each leg. This allows the user to put the suit on and off without removing the boots. If needed, one can also unzip from the waist down to get into their pants pockets. Elastic at the ankles and wrists keep the bees out. Wrist closures are adjustable. The hood is roomy and provide good visibility and protection as well.

The Ultra Breeze advantage for the Commercial Beekeeper With its superior workmanship and materials, The Ultra Breeze stands up to the demands of commercial beekeeping. The users will be cooler, more productive and less likely to suffer heat- related problems when wearing the Ultra Breeze. And the outstanding protection against stings allows the team to work more efficiently and safely, even with hot hives and in areas with Africanized bees.

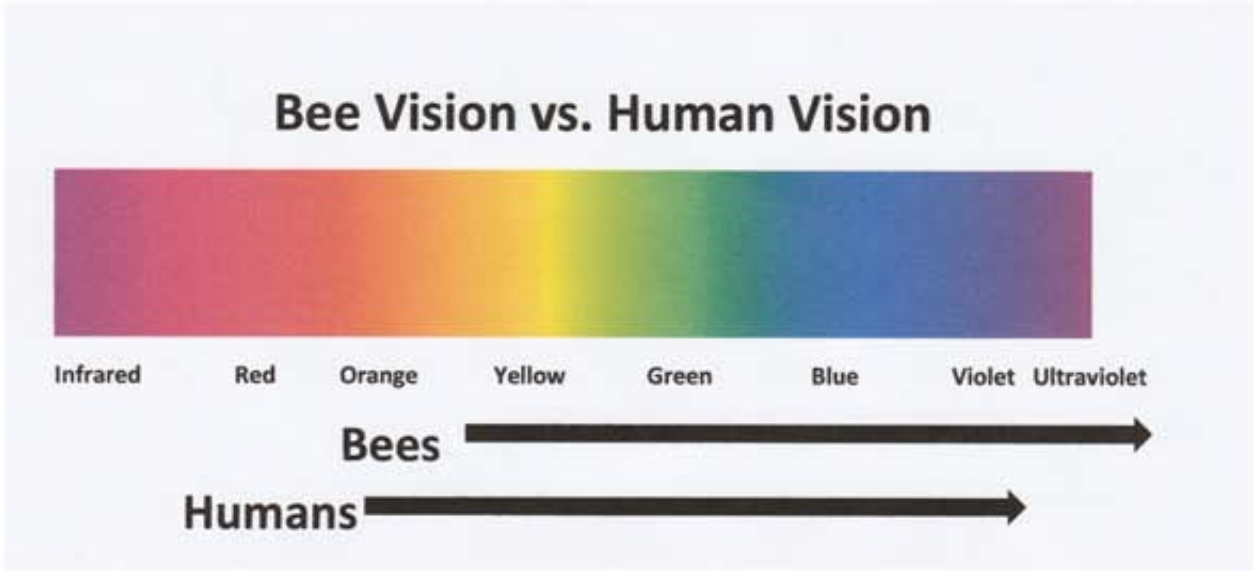
Ref: http://www.ultrabreezesuits.com/

Chapter 4

Researches on Honey Bees

Researches on Honey Bees

a. How honey bees see and why is it important



The eyesight of bees has long been a source of fascination in the scientific community. Even though humans can see more colours, bees have a much broader range of colour vision. Their ability to see ultraviolet light gives them an advantage when seeking nectar. Many patterns on flowers are invisible to humans. These nectar "bulls-eyes" are visible only to animals, such as bees, that have the ability to see ultra-violet light. This "bee vision" makes finding nectar much easier.

Like us, bees are trichromatic. That means they have three photoreceptors within the eye and base their colour combinations on those three colours. Humans base their colour combinations on red, blue and green, while bees base their colours on ultraviolet light, blue and green. This is the reason why bees can't see the colour red. They don't have a photoreceptor for it. They can, however, see reddish wavelengths, such as yellow and orange. They can also see blue- green, blue, violet, and "bee's purple." Bee's purple is a combination of yellow and ultraviolet light. That's why humans can't see it. The most likely colours to attract bees, according to scientists, are purple, violet and blue.

Ref: http://www.beeculture.com/bees-see-matters/

Researches on Honey Bees

b. Bee biology

It is important to understand the anatomy and the behaviour of the honey bees, in-order to get an idea of how a stinger works and behaves to make the suit prevent it from penetrating or reaching the skin.

The sting itself is a small, efficient, well-engineered device that allows the bee to defend its own life and its nest, against predators.

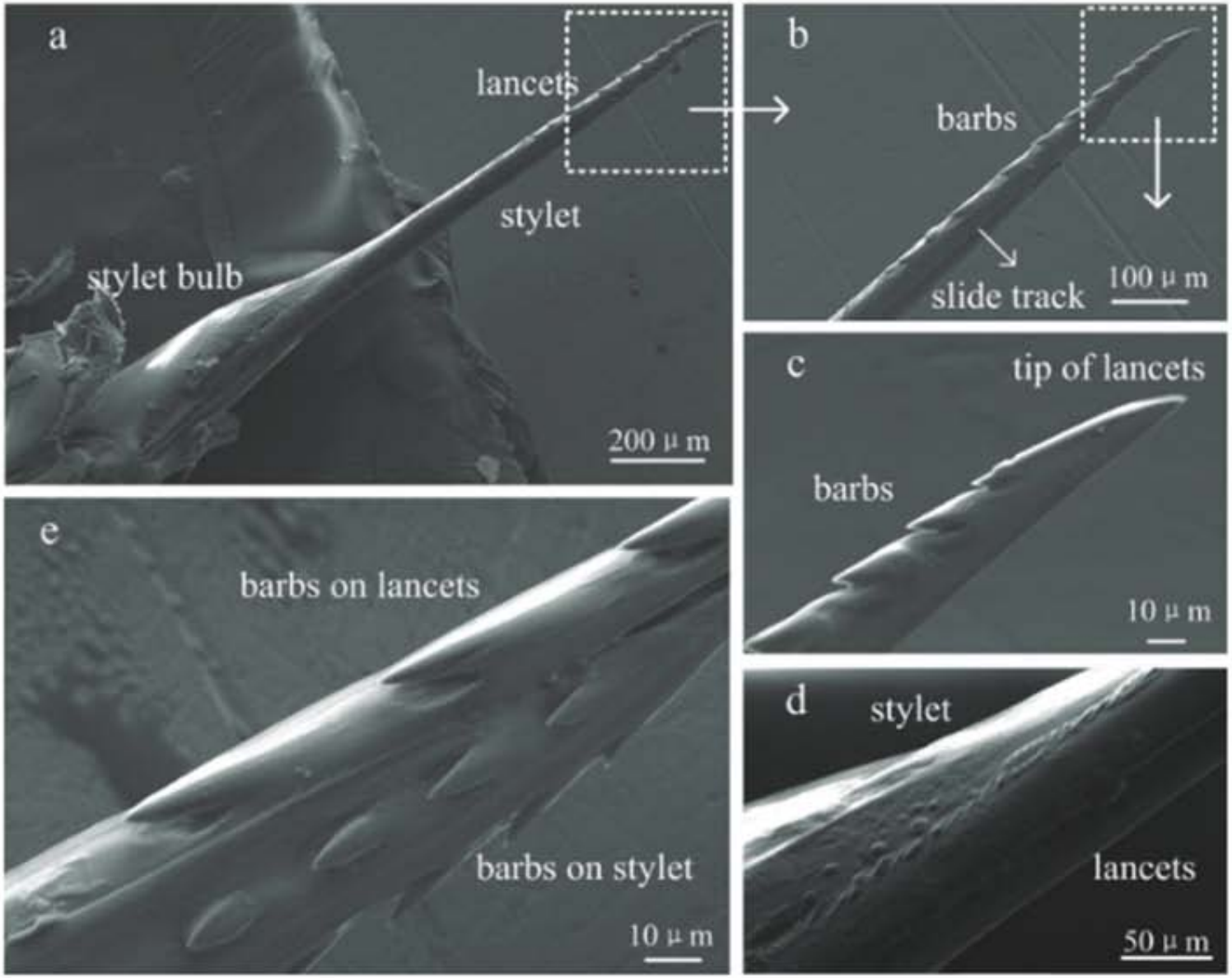
When the sting is deployed, the bee bends its abdomen downward due to the actions of the muscles that connect the abdominal plates. The muscle set on the ventral side contracts thereby increasing the overlap between the sternite plates. On the dorsal side another set of muscles contract so that the membrane between the tergite plates is distended. This results in a bent abdomen, which in combination of the angular ventral movement of the sting shaft. This ensures that the sting shaft enters roughly perpendicularly into skin of the victim. Perpendicular penetration is the most efficient as venom is delivered more deeply and the path through the tough skin is shortest. The force from the bee's legs, the muscles of the abdomen and the effect of the backward raked barbs, as the lancets reciprocate alternately, all combine to produce a thrust that drives the penetration of the sting.

Venom is pumped into the central canal by the reciprocating action of the lancets, each of which has an umbrella like collector and valve. The pulses of venom are delivered through the canal and squeeze out between the rubbing faces of the two lancets.

Ref: http://www.beeculture.com/bees-see-matters/

Researches on Honey Bees

b. Bee biology



Ref: https://www.researchgate.net/publication/301316684_Insertion_and_Pull_Behavior_of_Worker_Honeybee_Stinger

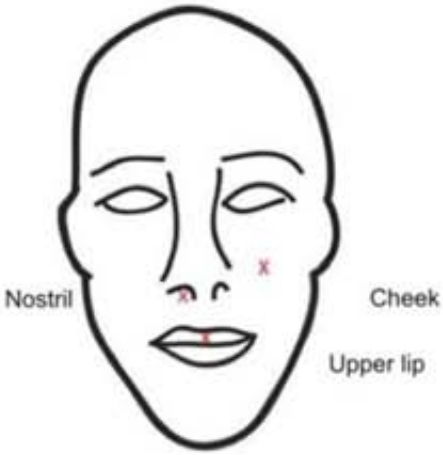
Researches on Honey Bees

c. Bee sting pain index

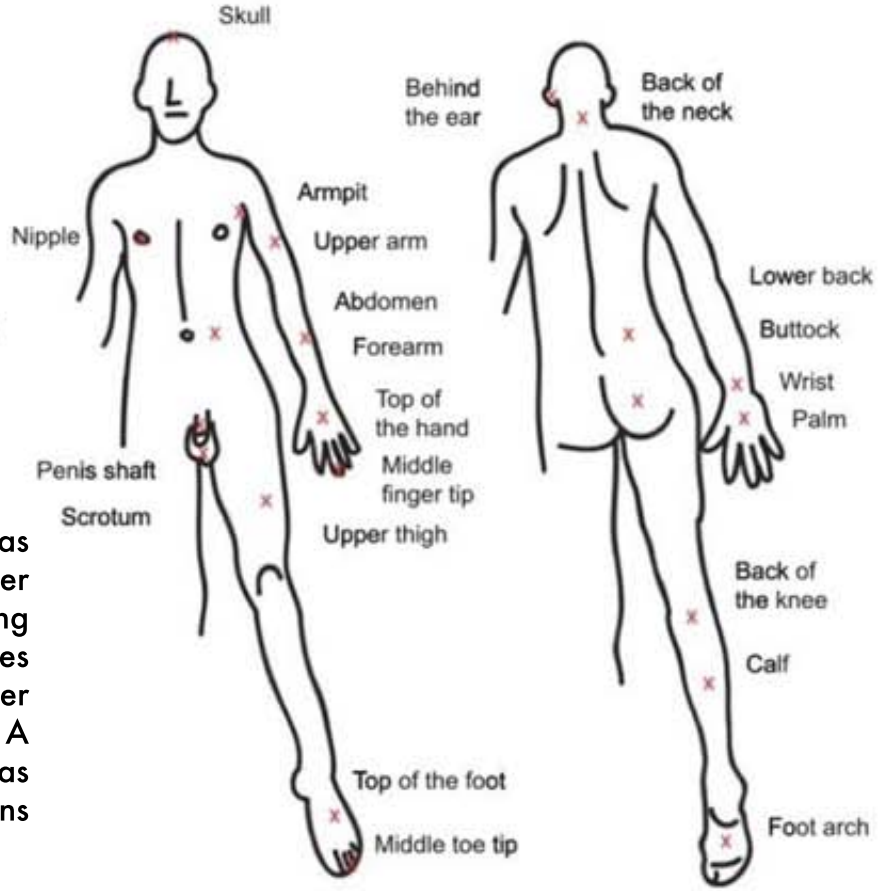
The Schmidt Pain Index was developed by Dr. Justin Schmidt, an entomologist, as a method for comparing the pain of various different insect stings he experienced during his work. The scale runs from 1 to 4, with four being the most painful. Pain can be subjective, varying from person to person, and this scale is therefore not absolute.

http://www.compoundchem.com/wp-content/uploads/2014/08/The-Schmidt-Insect-Sting-Pain-Index.pdf

25 sting locations were selected throughout the body. One location (forearm) was selected as an internal standard, with the a priori assumption that stings to the forearm would induce a median level of pain. The author self-administered five stings per day. The first sting and last sting were the internal standards (forearm). These stings were given a score of "5", and the three "test" stings were rated relative to the pain of the forearm stings. All stings occurred between 0900 h and 1000 h, to avoid time of day effects.



At least 5 min of delay was given between stings, longer if pain from the previous sting persisted. Lower scores denote less pain; higher scores denote more pain. A numerical rating scale was used to simplify comparisons between sting locations.



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3994616/figure/fig-1/

Chapter 5

Visit to Wardha

The Centre of Science for Villages (CSV)

primary goal of the centre is to "improve life conditions in the rural areas of India". The techniques evolved by the CSV range from mud housing technology to various methods of energy procurement and crop cultivation. CSV actively works in the areas of promoting hygiene and development of alternative approaches of local industries. These techniques are primarily based on locally available materials. They are simple to use, cost effective and environment-friendly. Training to villagers is provided in parallel, so that they can enhance their skills and transmit their experiences to others. This initiative enabled the creation of a local know-how that can be used to create opportunities of jobs, trades, etc.

Activities are planned on the basis of the Gandhian philosophy that envisioned villages as self-sufficient units. The use of these "appropriate technologies" brings freedom for villagers and helps them to lead their life with dignity.

CSV works to salvage traditional sciences through appropriate technology transfer and introduction of practical and innovative scientific products for rural areas that benefit both the people and the environment. The two campuses of CSV at Kumarappapuram and Dattapur in Wardha organise a wide variety of activities exhibiting the application of alternate technologies for rural areas both through models as well as through hands on practices in their own facilities. At these locations, CSV also provides training to artisans, Self Help Groups, micro-entrepreneurs and development practitioners on alternate technologies. Key areas of work of the organisation are Rural Housing, Sanitation, Liquid waste Management, Non conventional Energy, Eco technologies and rural industries.

Visit to Wardha

b. Case study

Their Principle behind the honey production units is that they try to breed and harvest honey without crude methods. Honey from Rock Bee is collected from the forest villages across the country and sold to the trader at different locations. But unfortunately this honey is collected by traditional method which is very crude and destructive, causing Loss to Bee population; Hampers the cross pollination service rendered by honey bees to our agricultural crops and forest vegetation, which ultimately results into ecological imbalance. The use of fire in this traditional method is also responsible for burning the standing forest wealth.

To make honey collection technique non violent and eco friendly "Centre of Science for Villages", Dattapur, Wardha has evolved a set of appropriate and simple technologies which are non destructive and non violent. Technologies evolved and optimized by CSV are elaborated below.

Visit to Wardha

b. Case study

Though in other commercial beekeeping places, the beekeepers use variety of fabrics and garments designs to meet the diverse requirements and circumstances, in Wardha however due to lack of availability of variety of clothing nearby the beekeepers are suffering from several shortcomings. Although the novice beekeepers there have only physical issues, person who uses it for the first time might encounter psychological issues due to the lack of functionalities provided by the current suit in use.

Rock bees are ferocious in nature and they attack in swarm if they feel that their colony is likely to be attacked by an intruder. This natural instinct of rock bees has contributed a great deal in protecting this species from the aggressive nature of man and animal alike.

To get protection from these ferocious bees while handling their comb it is essential to protect a honey hunter. To achieve this task a sting proof dress is designed which provides full protection to the honey hunters and his helpers.

The sting proof dress is made up of double layered thick cloth having a number of air passages. The dress consists of 5 items. A mask having a plastic wire gauge on front side to protect the face of a honey hunter, The mask is attached to the jerkin which protects the body of the hunter, A pair of hand gloves to protect palm of a person, A pant to protect body parts below the waist, Foot gloves to protect feet. The dress is edged with Velcro linings instead of button strips to make it easier to put on and off.

Visit to Wardha

b. Case study

Water spray Stinging behaviour of rock bee is initiated by temperature factor prevailing in the bee colony and it results in to their collective attack on the victim. To overcome this problem, plain water is sprayed over the rock bee colony which mollifies the bees and restricts their free movement as their wings get wet and colony temperature comes down. A simple handy water spray is required to spray the bee colony at their nesting spot.

Rope Ladder Rock bees are accustomed to have their abodes at the inaccessible high spots and hence it becomes difficult reaching and handling them at such spots. To overcome this difficulty a light and portable rope ladder has been designed and made by using nylon or cane rope. Nylon or cane rope is thrusted with a steel wire in it to increase its strength. Both the rope pieces are twisted having parallel knots to each other to support the solid bamboo pieces as steps of the ladder.

Visit to Wardha

b. Case study

The method of honey hunting varies according to the nature of the support, number of colonies in aggregation or singly. There are many traditional methods that are followed in different regions for honey harvesting. Honey hunters have to climb steep cliffs or ascend tall "bee trees" by hand-made ladders during the darkness of the night then keep bees away with smoke and cut away the comb completely for collecting honey. This technique is a very strenuous, laborious and demanding job.

A metal piece is tied to a end thin rope which is then thrown over the bee hive containing branch. The end of the portable rope ladder is tied to the other end of the thin rope and then hoisted up by pulling the metal end of the thin rope.

The rope end of the ladder is then tied to a adjacent tree firmly and a second harvester holds the rope ladder in the ground while the primary harvester climbs the rope ladder with his accessories tied to his body.

The primary harvester reaches the beehive containing branch and then a bucket with knife is hoisted by the same method as ladder hoisting. The harvester uses the knife to slice off a part of the comb and leaves the rest. He uses the same bucket to collect the honey combs.

Visit to Wardha

b. Case study

If the honey comb is reachable by hand, they use their water sprayer to spray on to the comb to make the bees wet making it difficult for them to fly around. Then the harvesters neatly slice off a part of the comb and leave the rest in the tree.

If the comb is small and is not reachable by hands, the hunters use a long bamboo stick with a knife tied to its end to cut the comb. Usually 3 or 4 men are sufficient to harvest honey by this method. A fire is lit on the ground just below the nest, to drive away the bees. Two of the harvesters spread out a net and hold it below the comb. Another harvester cuts off the honey comb using a long bamboo stick with a knife tied to its end. The honey combs which drops into the net are collected by the harvesters. The honey is squeezed into a large vessel and stored in large cans.

1. The main issue is the lack of ventilation, while its being used especially during summer middays.

2. The lack of ventilation is even worsened by the weight of the suit. The suit is feels heavy over time.

3. Though gaps for ventilations are required, it shouldn't be so big enough for the bees to enter.

4. Wearing the suit is cumbersome due to number of parts which includes jacket, pants, head veil, gloves and socks/shoes.

5. A person cannot wear the suit without the help of second person since the order of wearing restricts the wearer from self-wearing.

6. The fabric of the current veil is also a bit thin providing no adequate protection. So they have used two layers of fabric.

7. The bee veil does not provide adequate viewing angle and is not fitted properly to the head though the distance between the face and the net is appropriate.

8. There are no pockets/loops for carrying other accessories.

9. The suit has gaps at waist, foot and wrist locations which could invite bees to enter.

10. There are no flaps covering the zips or the closing providing the second line of defence from the bees entering the suit.

11. The rubber gloves were not being used on a regular basis since the user cannot manipulate minute works and its not comfortable at the same time.

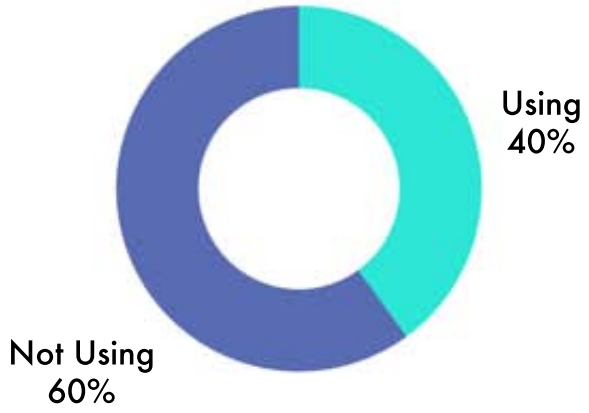
12. The upper end of the gloves has loose openings.

13. Though the ankle part has elastic closing there are some gaps present and feet were exposed since there were no/less usage of ankle socks.

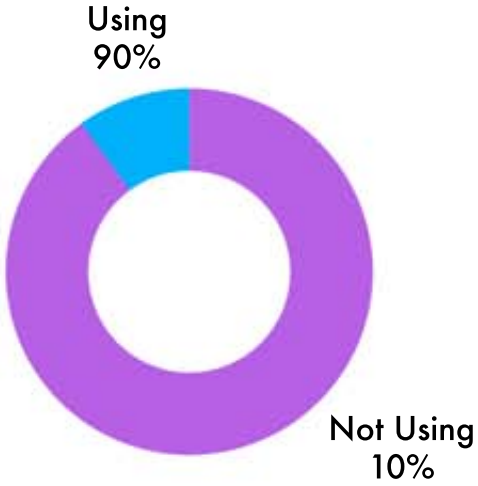
14. The Beekeepers simply prefer not to wear the suit because of these issues on top of it being not so comfortable as well.

Visit to Wardha

d. Survey on the suit wearers

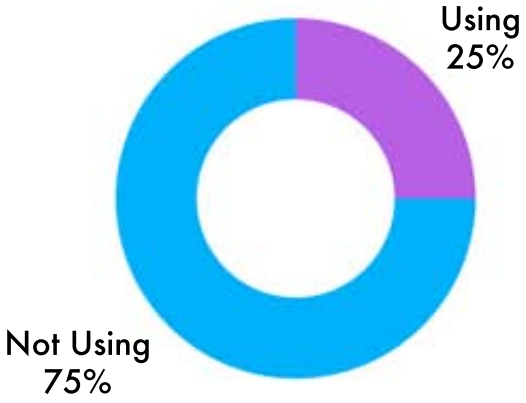


Protective suit



Head veil

This is a survey conducted by a group of researchers at IIT Delhi with 100 beekeepers. The surveys shows that there are only about 40% of them who wears the suit on a regular basis. While the numbers of the weareres of gloves and shoe/socks is significantly low. This is mainly due to the isses that we discussed earlier.



Gloves

Shoe/Socks

http://mgiri.org/wp-content/uploads/2014/05/Development_of_Protective_Clothing_for_the_Indian_Beekeeper.pdf

Visit to Wardha

e. Need for protectective clothing for beekeepers

1. For providing protection against bees' stings from head to toe.

2. For providing protection in different climatic conditions and especially during summer.

3. To reduce the risk of allergy in family members through contaminated clothing.

4. To minimize the loss of bees.

5. For providing professional identity to the beekeepers.

6. For minimizing the physical harm and feeling of insecurity amongst the beekeepers or any user.

7. For boosting the confidence to new upcoming beekeepers.

8. To ensure the smooth working with several beehives and to get higher efficiency.

Chapter 6

Ideations

Ideations

a. Initial ideations from brainstorming

Using paper mesh, polyester, nylon or polypropylene nets.

Invisible suit | Smoking suit | Foam jacket

Neoprene suit | Ultrasonic suit | Electrically charged suit

Using things that attracts the bees away from the beekeeper.

Camouflage suit | Water/Air filled suit.

Aluminium foil/coating to reflect sunlight from the suit.

Kevlar suit, Jute sac layered suit, Knit wear (prime, Fly knit)

Padding Jacket | Bubble wrap like cloth | Bear suit

Perforated suit, Multi-layered mesh/porous cloth.

Rings suit | Umbrella structure hood | Baloon suit

Ideations

b. Initial ideations

The initial idea is to address the part where the suit is difficult to wear because it consists of several parts which makes the wearer take more time as well as other issues such as the issue with the wearing order.

The first idea is to have one single comprising of a single part. For example, the jacket, the pant, the gloves and the head veil can be stitched together so that the wearer can wear it in a single go. This idea can be incorporated in whatever the fabrics are to be used later in the process.

However, the issue with this concept is that if the gloves part or the socks part gets damaged the entire suit has to be replaced. But by borrowing the modular concept where the gloves or the socks can be replaced this issue can be solved.

Since the suit is one single suit unit there has to be something that holds the suit in the place. By stitching an elastic belt near the abdomen the suit can be held into place like how a pant is help into place. The head veil can also be attached/stitched to the jacket which can be readily worn with the jacket.

The zip can be at the back unlike a traditional one where the zip is at the front. This is so since the pant and the jacket are together and so when the trouser is worn the jacket would be in the front rather than at the back. So the wearer can see the jacket which is in front of him.

The head veil would be made of two parts the fabric and the net. It resembles a sweatshirt where the top part can be made of fabric which can be rest on top of the head while the rest of the veil can be made of net on the front as well as on the sides so the user has more viewing angle.

The head veil has to be collapsible since the suit has to be folded. So the collapsible structures and collapsible products were studied. For example, the collapsible laundry bag which has steel wire which are flexible at the edges and the sides can be made from either fabric or meshes. The steel wire the edge is typically stitched with a fabric around it while the fabric is stitched with polyester mesh from edge to edge. The whole thing can be twisted and can be collapsed into a tiny package.

Similarly, the car window shades can be twisted and collapsed into a small package for storage. Similar concept can be used in the head veil where it can be collapsed while the rest of the dress can be folded. And the mesh can prevent bees from stinging whilst also providing ventilation.

Another way to protect the beekeeper from getting stung by the honey bees is to somehow keep the bees away from the suit by means of several natural or chemical substances such as cinnamon, peppermint oil, cayenne pepper, garlic liquid, spices and tea tree oil or chemical agents such as moth balls or baby powder. These substances are believed to have resisting power from the honey bees.

Once the bees are attracted to a place nearby and and the apiary that need to be worked on is empty then the apiarist can go ahead and process it without having to worry about the bees since the bees are away from the apiary. The natural/chemical agents can be anything from a fruity to a flower scent. Any food odour that a bee would want to sit on.

These agents or substances can somehow be incorporated into the suits by some techniques which would prevent them from getting stung by the bees since they cannot even sit on the suit in the first place. For example, the substances can be mixed with water and the suit can be soaked in it over night and then be worn in the morning. The downside to this is however, chemical agents are harmful to humans as well. Another way to to attract the bees away from the harvester by attracting them to some other place by using flower scents.

Another way is by getting to know the most painful area in the body and the most stung areas on the body and giving them the preference over other places and protecting these areas with meshes for ventilation. Besides this the suit has to be in a lighter colour to prevent them from heating up in the hot summer as well as by not being mistaken by the bees as a bear or a racoon.

Ideations

c. Concept developement

The first concept is the one where we try to harvest honey when wearing a suit that is either naturally repellent to the bees or using any chemical/natural agent to detract the bees away from the suit.

Another way of keeping the bees away from the suit is by understanding how the bees see things and to find a way to be invisible to the bees. The bees see in UV spectrum. In a UV spectrum any darker colours are almost black and the whites are white and the bees recognize a moving object by the difference in contrast. If we could use a cover like a tent over the honey harvesters that is white in colour and wearing a white suit so that the background and the foreground is white and there wouldn't be a difference in contrast. That could make us invincible to the bees.

The second concept is where we use a thick enough fabric on the entire suit so that the sting of the bees does not reach the other side of the fabric when stung. The fabric at the same time has to be properly porous enough to allow air flow.

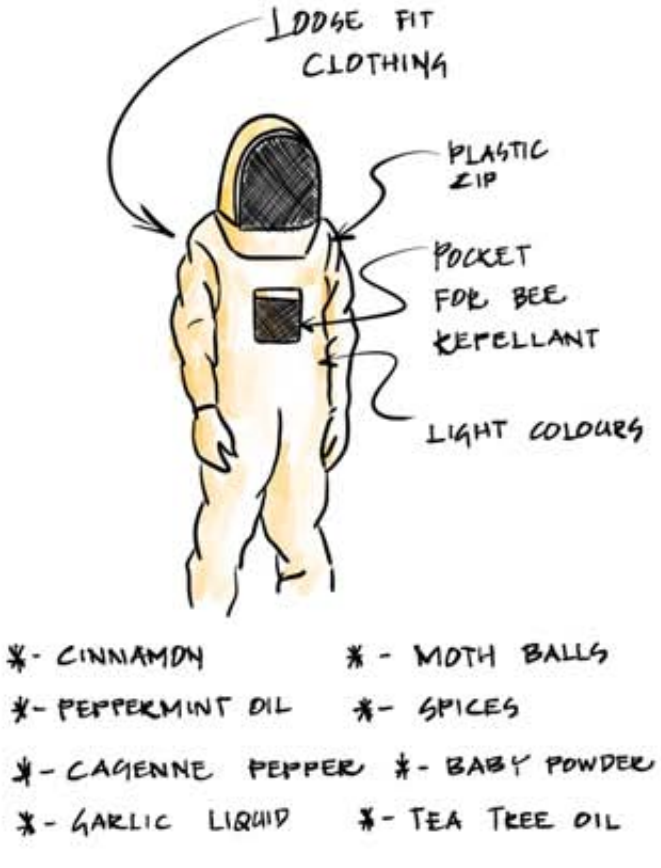
An intensive fabric study and exploration needs to be done make this concept a reality. One aspect of the project is also affordability. If the suit is crazy expensive the poor tribal people are better off using the current suit. The fabric also has to be inexpensive.

The third concept is where we could have a strong enough fabric so that the bee sting does not even penetrate the suit and reach the other side of the fabric. But when we use a strong fabric air flow will be significantly cut off which has to be taken care of carefully.

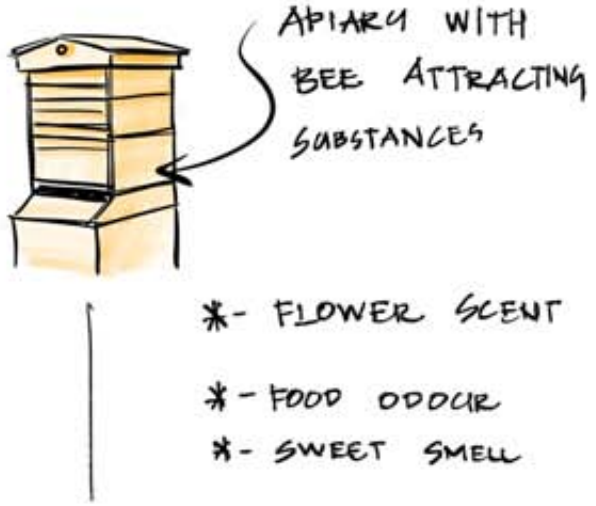
Parts of the suit can be cut and covered with meshes where the pain from a sting is less and we can afford to get stung in these areas. Places where the bees sting less are also good places for keeping the mesh window. Having said that one needs to be aware of the fact that the place where these windows are there are vulnerable to the bee stings.

Ideations

c. Concept 1



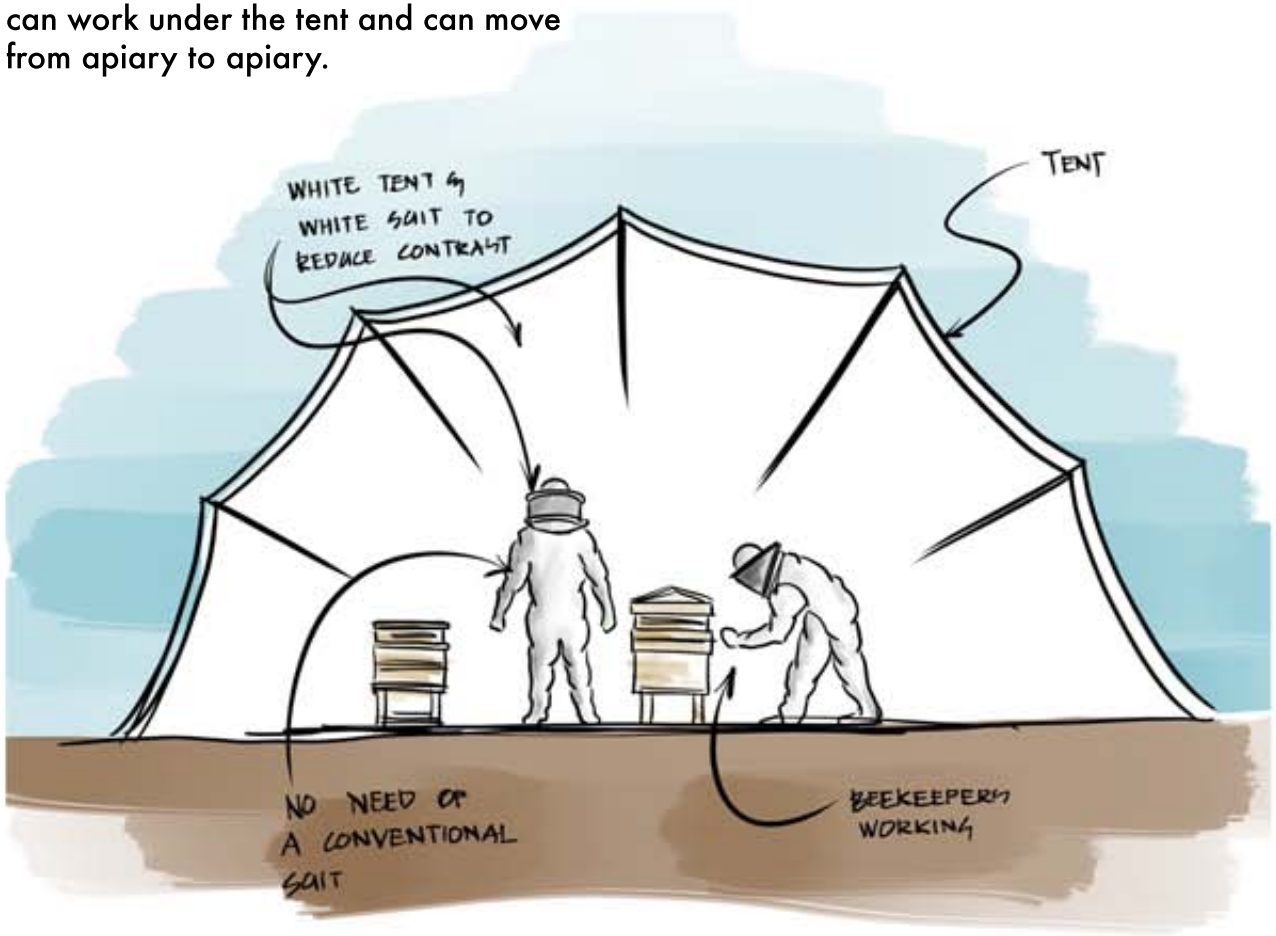
Natural/Chemical agents such as cinnamon, peppermint oil, cayenne pepper, naphthalene balls and other things mentioned below are things which in someway can be incorporated into the suit or made into an solid form which can be kept on the suit to prevent bees from sitting on the suit which inturn would stop/minimise bees from stinging the beekeeper.



Ideations

c. Concept 1

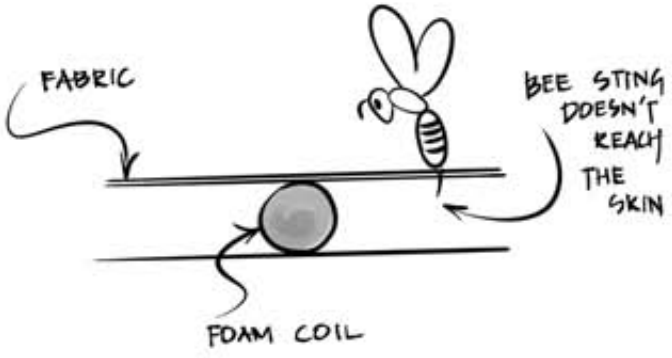
By using a cover over for the apiary and the apiarist in white colour while the apiarist also wears a white coloured suit, the contrast difference can be minimised for the bees to differentiate from the background and the beekeeper which in a way would act as an invisible suit. The beekeepers can work under the tent and can move from apiary to apiary.

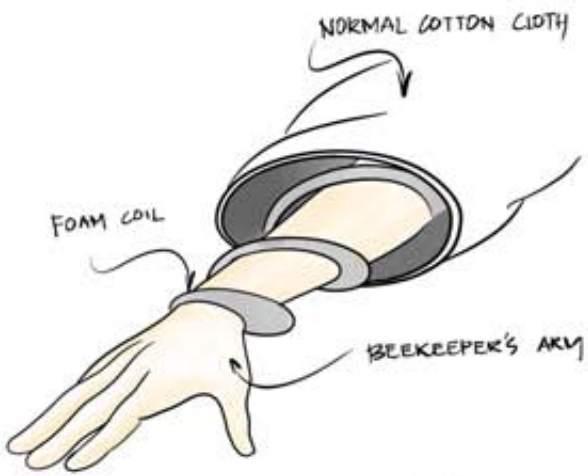


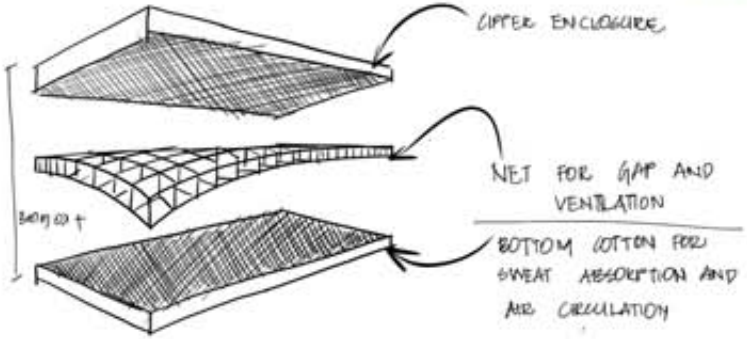
Ideations

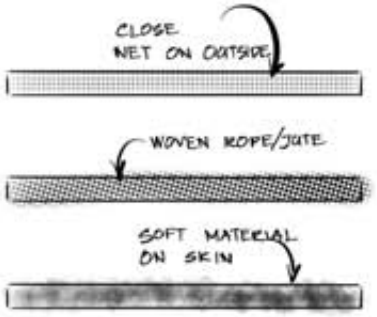
c. Concept 2

By creating a thick fabric by multilayering several fabrics, we can create a fabric that is so thick that even if the bee stings pass through, it cannot come out the other side. For example, we can multilayer thick net fabric and stitch it with an enclosure on the top that has small porous surface small enough to not allow the bees and big enough to allow ventilation.



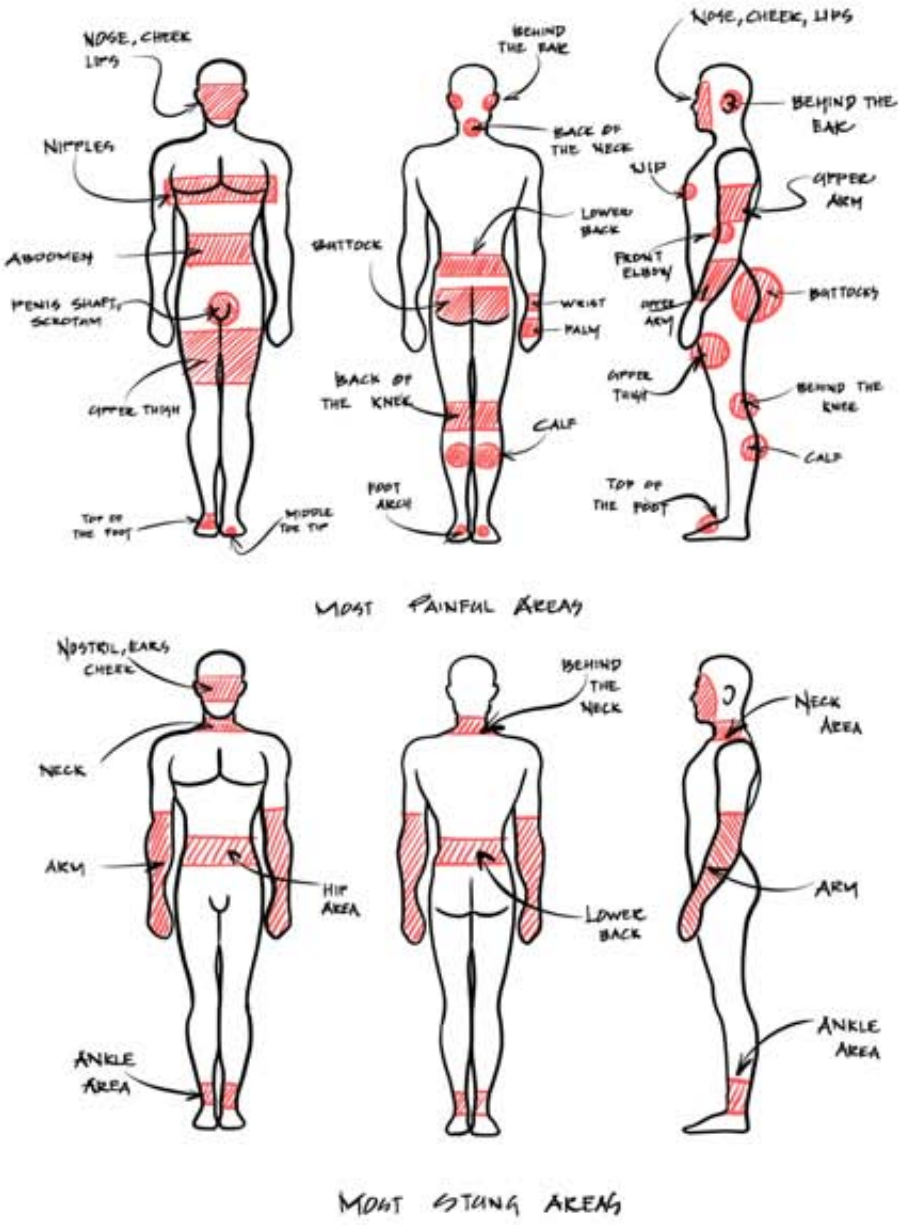






Ideations

c. Concept 3

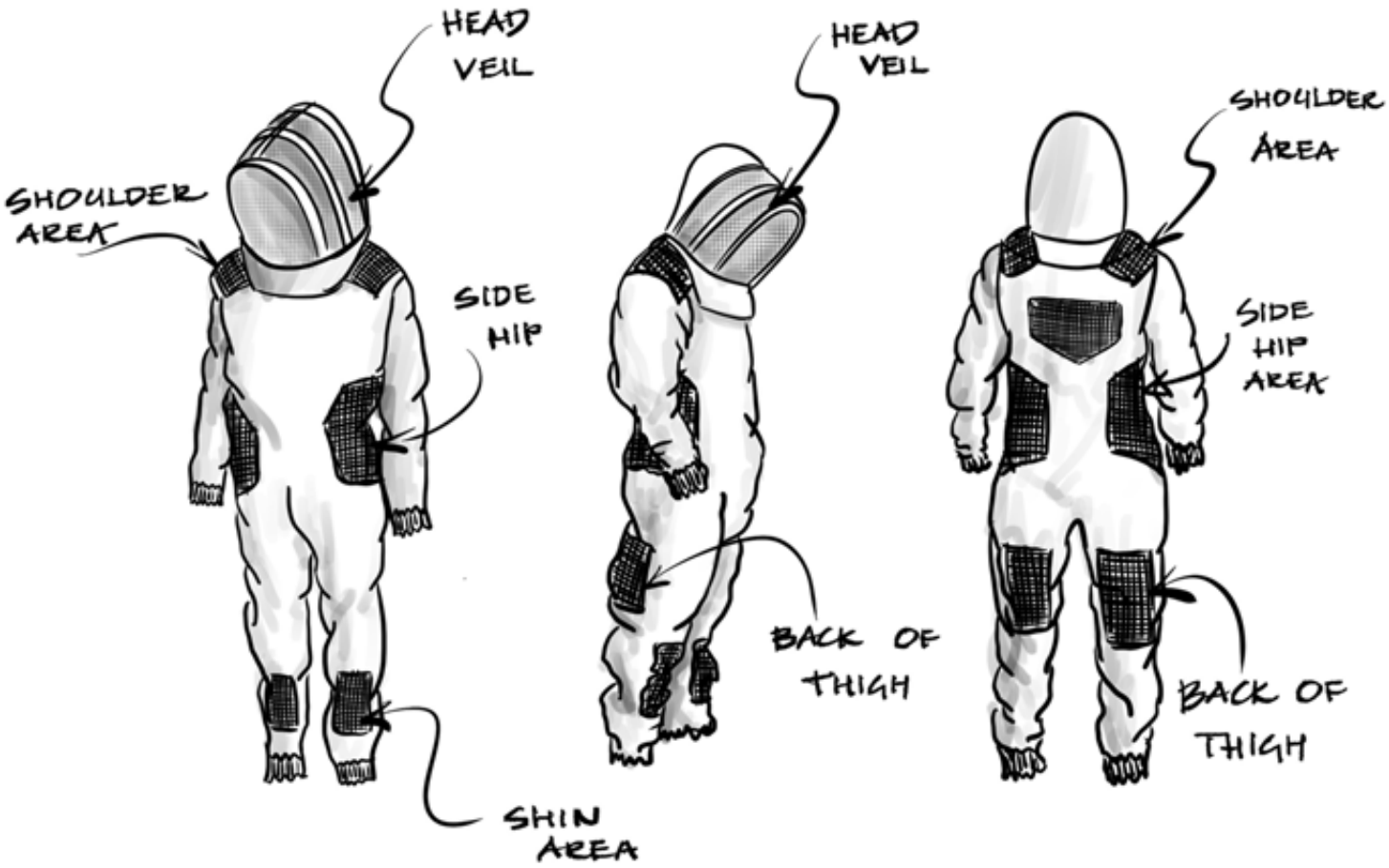


By understanding the areas that are most painful to be stung by the honey bees and areas where the honey bees sting the most, we can learn about the areas on our body where it there is less probabality of getting stung by the bees and even if the bees sting, it would pain less. For example, our shoulder are one of the area in our body where the bees sting less and even if the bees sting, it would pain less. We can take adavantage of these areas and place ventilation meshes to promote ventilation and stop bee stings by providing strong/dense fabric on the other parts of the body.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3994616

Ideations

c. Concept 3



POTENTIAL AREAS FOR VENTILATION MESH

Ideations

d. Concept evaluation

Concept one is where we would use agents to deter bees away from the suit. Of all the three concepts, the first concept is the most expensive one since the agents have to be bought every now and then. And on top of that it is not an easy to use concept. One has to not only use a suit but also handle the agents the before night to apply or whatever on the suit. It not only takes time to do all these processes but also cumbersome and the agents are not good for the health of the user. The agents are strong enough to not only weaken the bees, but also kill them.

As far as the tent concept goes, it has similar drawbacks. It not only has just the suit but also an another component to the product which is the tent. Similar to the first ideation its not just expensive but also time consuming to use them. So the people at wardha did not prefer the first concept.

Concept three is where we're trying to use a strong enough fabric to stop the bees from stinging. The fabric that we're trying to use is to be so strong that the bees cannot even sting through it. Apparently there is no such thing as impenetrable fabric. The sting of the bee is so minute and works in a way that it could penetrate almost any soft fabric. And on top of that the ventilation would be completely cut off in the areas where we use the stronger/denser fabric.

We were also ideating to put ventilation meshes on the areas where the bees sting less and where it pains the most. The problem with that however is we're neither protecting the entire surface of the skin nor providing ventilation to the entire surface of the skin.

The stitching of all the ventilation mesh windows is not only going to cost a lot but there is going to be lot o places in the suit where its vulnerable to tearing since there's going to be a lot of connecting points. Besides that, the suit currently being used at wardha is also similar to this. So there very little change from that.

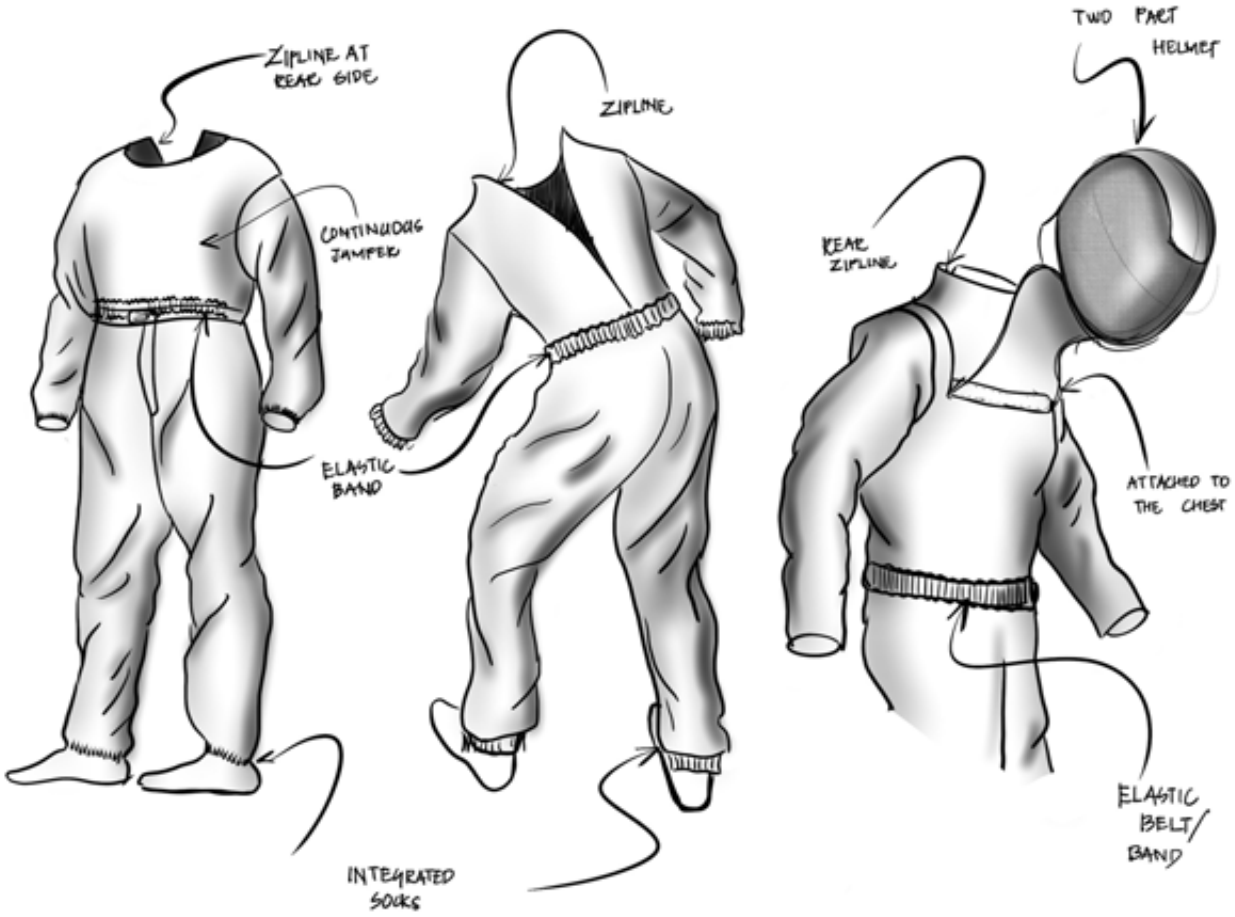
Concept two is where the idea is to have a thick enough fabric, so even if the bee stings the sting doesn't not reach the other side. Of all the three concepts, this had the most potential for success. So, it is decided that we take this concept further and more study were made to find the right fabric for this concept.

To meet the requirements, the fabric has to have several properties. The bee sting is about 1.7-2 mm long. So that fabric has to be thicker than that and it has to be porous enough for adequate ventilation as well. Initial ideations were to stack few different fabrics to create the thickness required. That is done by stacking plastic net, soft inner material and woven jute inside.

The problem with this however, there is a lot of work needs to be done just for the fabric. On top this the fabric has to be flexible and lightweight than the current one

Ideations

e. Ideations for the unified suit

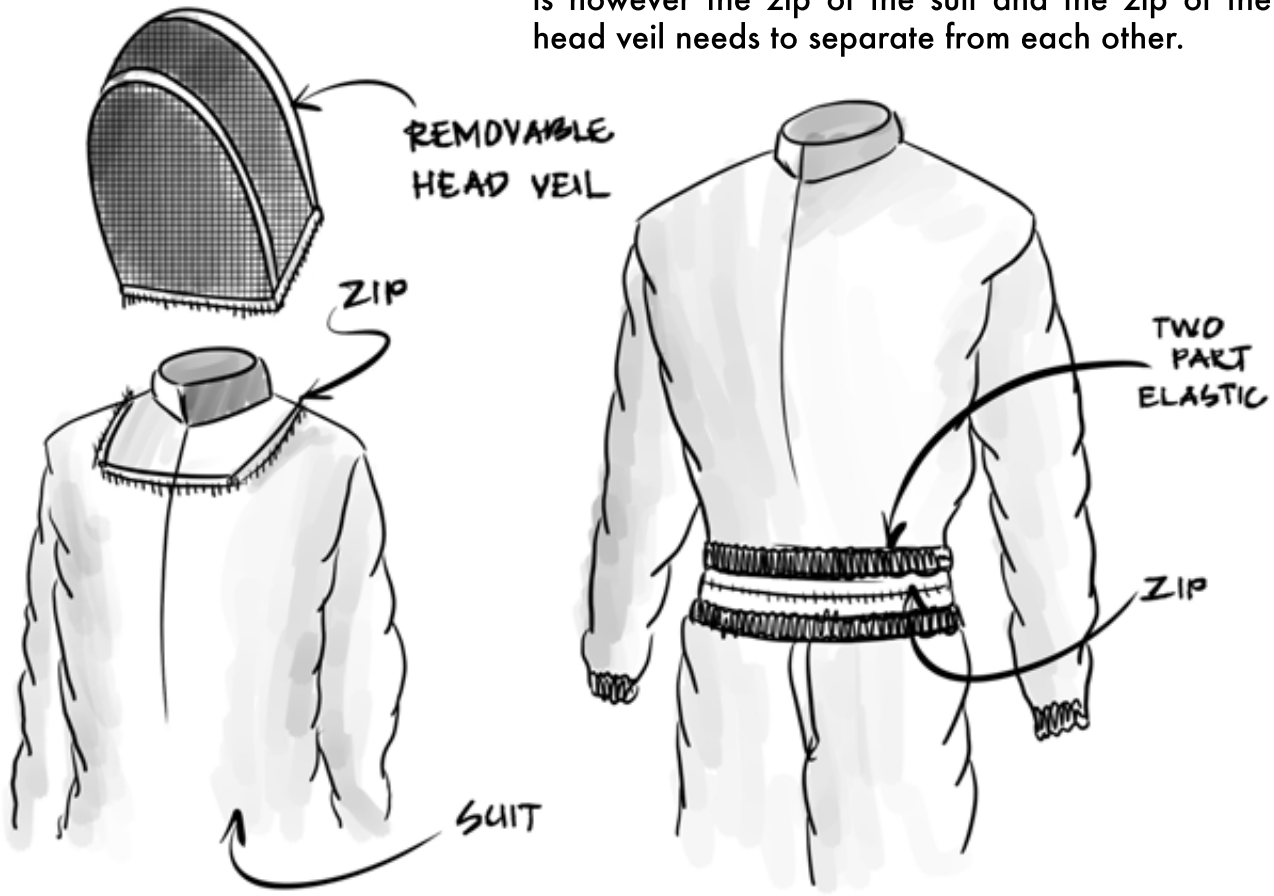


The jacket and the pant are connected together to address the ease of wearing issue. The hood can be attached to the jacket by means of a zip or velcro. The gloves and the socks can also be partially attached to the jacket and pants so when the beekeeper wants it can use it and when he doesn't need it, he doesn't have to remove it completely. The place where the jacket and the pant connects is where the elastic band is stitched to the suit for a tight fit. Elastic is also stitche to the sleeve ends and pant ends to cover it completely.

Ideations

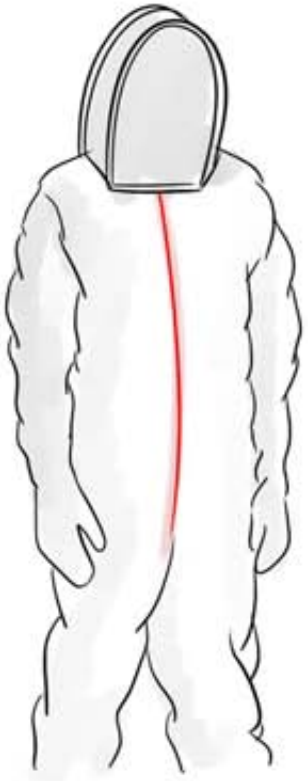
e. Ideations for the unified suit

Or another way to connect the jacket and the pant is to by connecting it with a zip and providing elastic band on either of the jacket ond the pant. The head veil can be made from a plastic mesh which can be attached and detached with a help of a zip. When the beekeeper does not need the head veil he can remove it by unzipping the zip that runs from one shoulder to another. The problem with this is however the zip of the suit and the zip of the head veil needs to separate from each other.



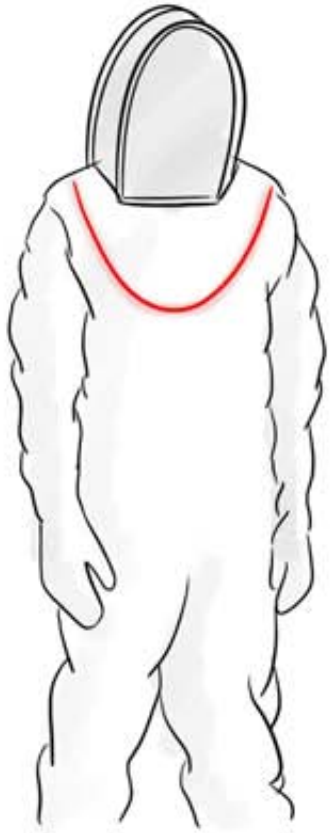
Ideations

e. Ideations for the unified suit



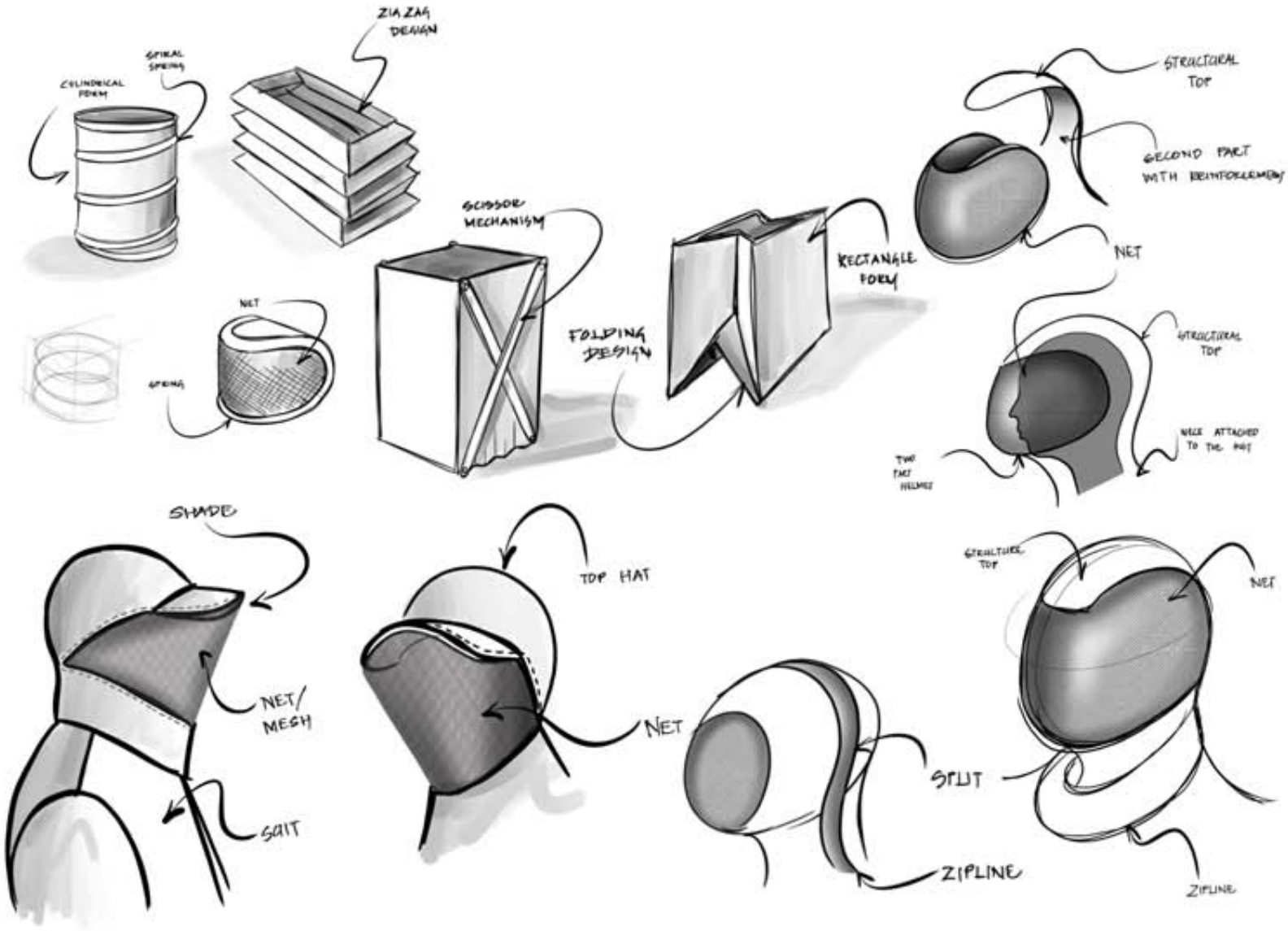
The placement and the shape of the zip line is very crutial to the suit. Just the placement of the zip and the zipline shape make the suit either really good or really bad. The zip has to be in a reachable position during emergency and it makes the suit easier to be worn by a single person. In this concept, the zip is placed right in front of the suit like a normal sweatshirt. The problem with this is however the zip cannot crossover the zip of the head veil which it did.

In this concept, the zip runs from one shoulder to another. This way the user can get into the suit from the top by putting his legs first and then his hands. The suit suspends from his shoulders while the beekeeper can put his hoddie on which hangs on the back of the suit. The zip is accessible at all the times and is easy to reach from the opening to the closing positions.



Ideations

f. Ideations for the hood



Ideations

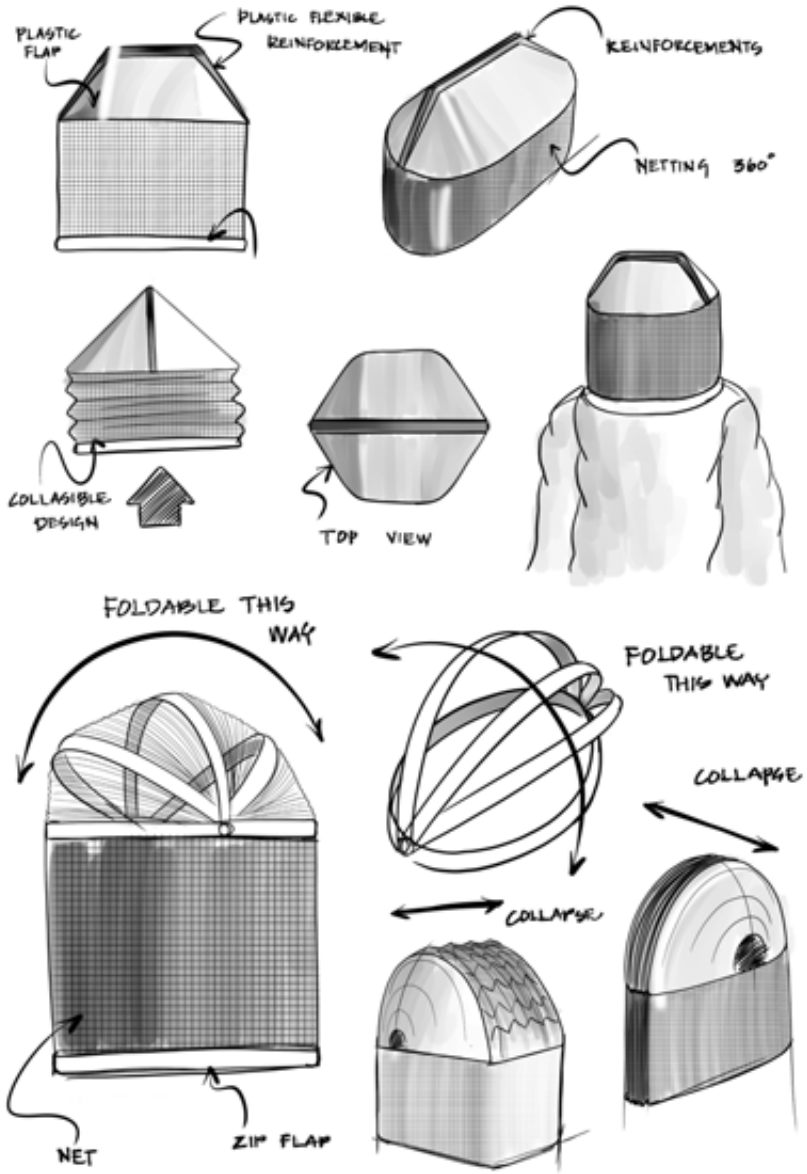
f. Ideations for the hood

Initially existing products like collapsible packaging bag and collapsible laundry bag were studied were the form and the features of the existing products were tried and tested. For the next one a hood that resembles the helmet was ideated where there is reinforcement on the top of the head from where the mesh can come down onthe sides and the entire thing can somehow be stitched to the jacket.

For the next one, a combination of a cap and a hoodie was ideated swhere the cap is stitched to the inside top of the hoodie and the sides are covered with nets which run down from the cap to the jacket.

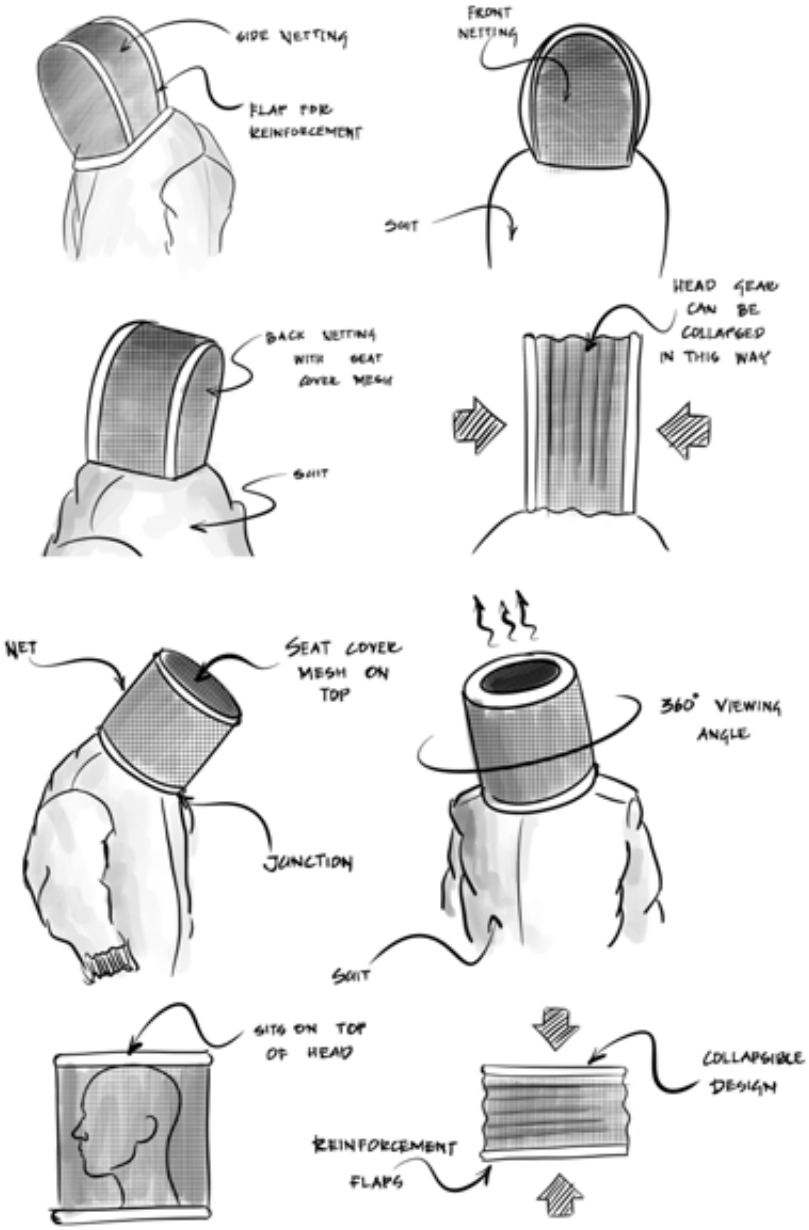
And for the next ideation collapsible baby nets were studies to see if the same concept and be incorporated for the headpart of the jacket. But the problem however would be the manufacturing process would be difficult and it would make it empensive as well. Things which can be opened and collapsed by pressing the top was ideated.

The Next one was like the one of a harmonium bellow which acts as the top of the hood while the nets run down from the top on the sides of the hood. The problem of manufacturing and costing were the issues in this concept as well.

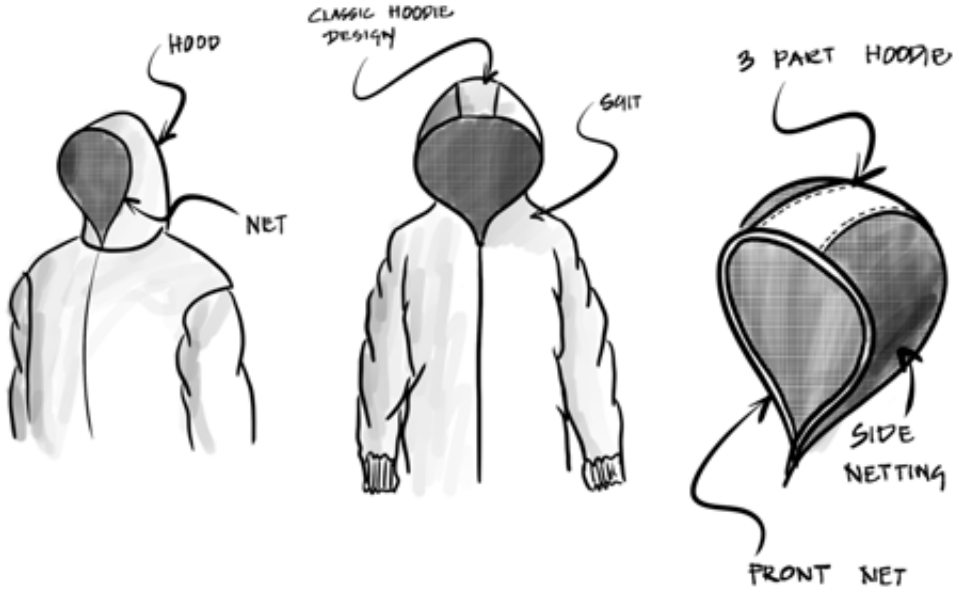


Ideations

f. Ideations for the hood



Costing is one of the major factor that has to be strictly considered while designing the suit. Same goes to each and every detail of the hood. There should be no extra details that would cost money. So simple designs were explored. Cyclindrical hood with a curtail wire running along the bottom edge and the top edge for reinforcements and to keep the hood net away from the face so that the bee stings does not reach the skin through it. Not onlu it has to be cheap and easy to manufacture, it has to be properly detailed out for it to function properly.



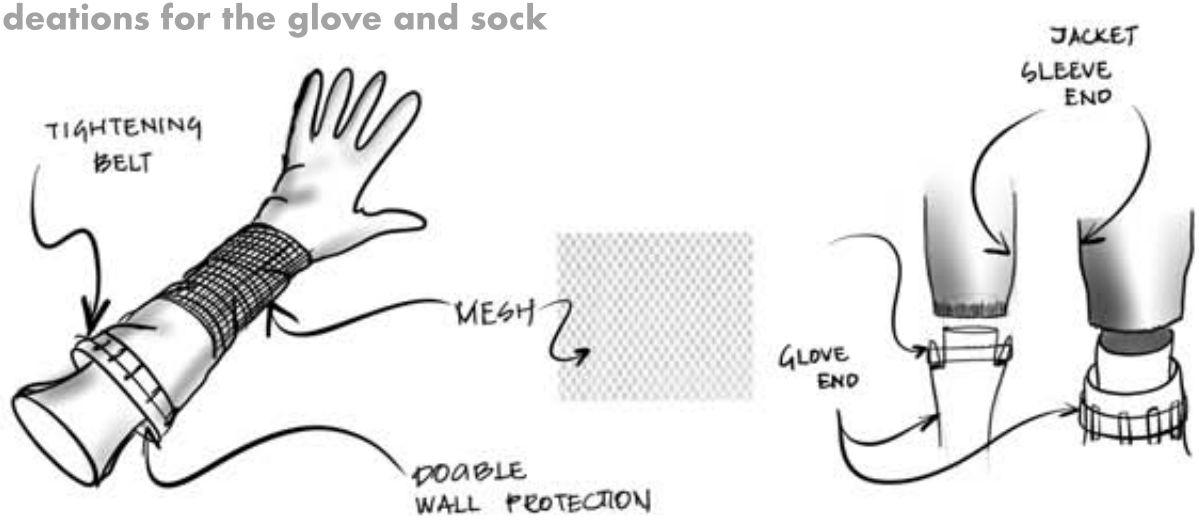
Ideations

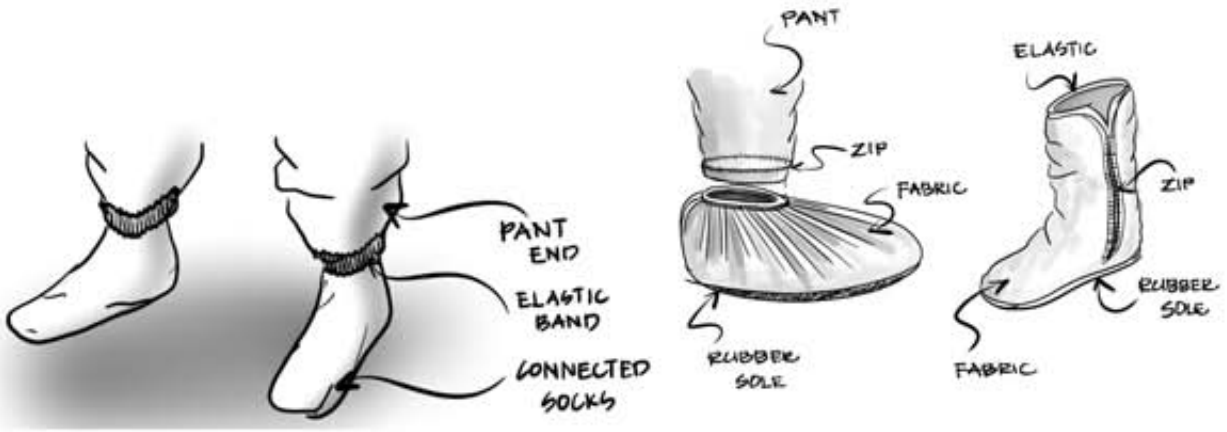
f. Ideations for the hood

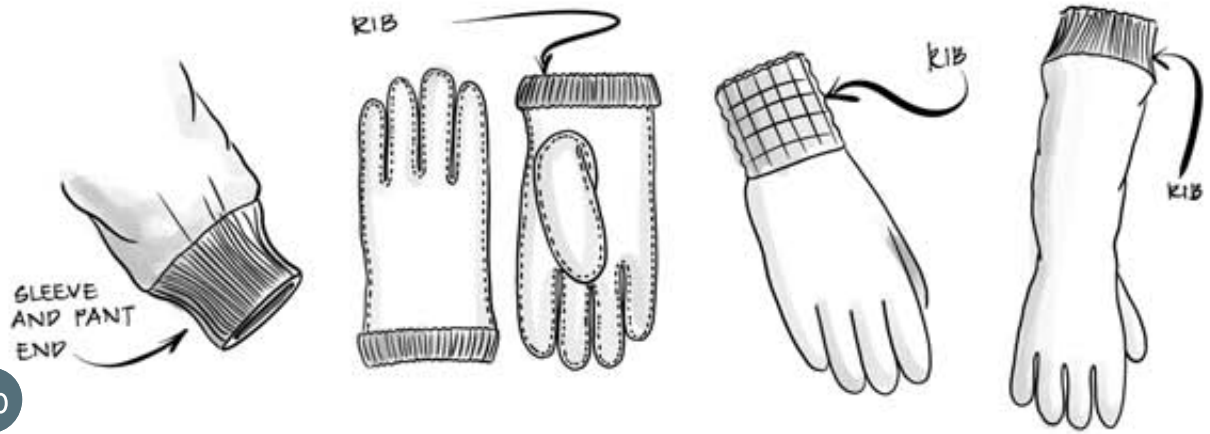
Since the manufacuring process was difficult and the cost of the entire hood was much higher, simpler designs were made. Simple designs such as the one that take the shape of a cyclinder or another one that is similar to that of the exising one but with cheaper materials and easy manufacturing were ideated. Another design was made like a hoodie where the net in the front had to be kept away from the face. To achieve that, a simple metal string/flat wire was inserted in a bent fashion so that the end of the bend keeps the net in the front away from the face. The last and the finalised one was the one that is made like a hoodie but the net was made like a cone to maintain a gap between the face and the net instead of the earlier metal string design was ideated. The conical net can be attached to the hoodie by means of velcro so that when the net gets damaged, can be repleaced easily.

Ideations

g. Ideations for the glove and sock







Ideations

g. Ideations for the glove and sock

The points where the gloves and the sleeve meets has to be properly secured so the bees do not enter through it. There are several ideations which were made, trialed and tested. There are three types, the zipped sleeve, the velcro sleeve and the rib sleeve. While the velcro and the zip sleeve was good ideas, they were not practical in a real scenarios. However tight the junctions were it was either not perfectly secured and there were always some gaps or they were not perfectly fastened at the wrist position. What the rib design does is that, it not only perfectly closes alll the gaps at the junction it is also perfectly secured at the wrist because of the elastric rib. Same could be used for the socks where the top end is fitted with rib, so one can wear it just like they wear a socks and its perfectly secured the way the gloves are secured. The bottom of the socks can be stitched with canvas.

Chapter 7

Making and Testing the Final Suit

Making and testing the final suit

a. Vendors visited and consulted

Sunrise International (Filter Division)
Jinesh Shah - 08048076328
No. 15 - A, Paras Darshan, Jagdusha Nagar,
Ghatkopar West Mumbai - 400086 Maharashtra, India

Payal Creation
Laxmiwadi Shed, Besides Maruti Suzuki Showroom,
Chinchpokli East,
Mumbai-400033, Maharashtra, India - RAJAN

Aala
8, Nakhuda Roghay Market, Nagdevi Street, Nagdevi,
Mumbai - 400003, Near Noor Hospital

Krishna Corporates
Room No. 614, 6th Floor, Cotton Exchange Building,
Kalbadevi Road,
Mumbai-400002, Maharashtra, India
Viral Dadia (Director)

Modi & Patel Filter Fab Private Limited
No. 306, Kakad Estate, 3rd Floor, Room No. 69,
Kalbadevi Road, Mumbai-400002, Maharashtra, India
Deepak Patel (CEO)

Tip top Seat covers
Shop No 6, Balaram Building, Balaram Street, Grant
Road, Mumbai - 400007, Opposite Bata Showroom

D. Chemet International
No. 208-A, A-Wing, Gokul Arcade Vile Parle East,
Swami Nityanand Road,
Mumbai-400057, Maharashtra, India - Raj Khanna

Hi tech Furnishing
5/37, Old Anand Nagar, Before Reliance Energy,
Santacruz East Mumbai - 400055
Maharashtra, India

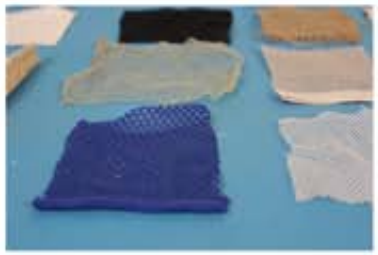
Natroyal Industries Pvt. Ltd. (natroyal Group)
No. 60, CD Shlok, Government Industrial Estate
Charkop, Kandivali West,
Mumbai-400067, Maharashtra, India - Natroyal
86

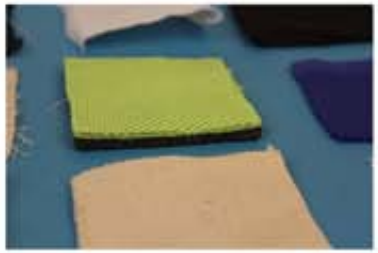
Arrow Technical Textiles Pvt Ltd.
C-216, Akurli Industrial Estate, ,Mumbai 400101
Akurli Road, Kandivali East Mumbai - 400101,
Maharashtra, India

Porwal Group - Venkatesh Industries
Plot No.78, Build.No.137, Behind
Aadarsh Mangal Karyalaya,,
Ichalkaranji, Maharashtra 416115

Making and testing the final suit

b. Fabrics explored





To find the right fabric, several vendors who deal with technical textiles are visited and swatches are collected from them. The images of the swatches are given above. Fabrics such as thick canvas, porous cotton, jute fabric, bamboo fabric, air-mesh, EPE foam, polyester nets and various forms of cottons were explored. Fabric that are thick and at the same time breathable is not the only constraint but also the colour, the texture, the flexibility, cost, life expectancy were also factors in deciding.

Making and testing the final suit

c. Mock-up making

Several fabrics were shortlisted from above and are taken further for mock-up making. Quick mock-ups made made using the fabrics collected either as a single cloth or stacked. For mock ups, Gloves was selected to be made since it would easier to make.

For testing, mock-ups of the gloves were made from the selected fabrics. Simple detail-less gloves without finger were stitched for testing. Different fabrics were stacked to form a thick at the same time ventilated fabrics were also stitched for testing.

Making and testing the final suit

c. Final mock-ups

Several fabrics were shortlisted to be made into mock-ups for further testing. Some fabrics were directly used to make the gloves, while some were stacked to create a thick gloves. Jute was woven to make a mesh on top of which a net and below a thin cotton lining was stitched to make one mock up. Plastic mesh was used as the top and on the bottom of which turkey towel cotton fabric was stitched as a lining and as a buffer. Mock-ups were made forearm length which can then be worn on top of the existing suit for testing.

Making and testing the final suit

d. Mock-up testing

The mock-ups were taken back to wardha for testing. Initially before testing, the people at CSV had a brief look at the mock- ups and wore it on their hands and tested for its comfort-ness, ventilation and feel of material on skin. Just by looking at the prototypes, they knew what all would work and which all wouldn't. So a final of three mock-ups were finalised to be tested on the bees. Only three were selected because the bees would die once it stings.

Making and testing the final suit

d. Mock-up testing

For further testing the mock-ups were taken to the apiary. The testing process is as follows. The mock-ups were tested for its weight, comfort-ness, feel on the skin, Ability to withstand bee stings, behaviour of the bees on the colour and the behaviour when disturbed wearing the gloves. After which it was tested for its ventilation capability bee behaviour indoors and outdoors after which they stood in sunlight wearing it on for testing its ventilation when used under sunlight while its windy and non- windy.

For testing it on bee stings, the gloves were worn under the current suit and kept on the apiary for which the bees did not react much. After which we grabbed hold a bunch of bees and held it for few minutes to see if it would sting or not. It did not react to the provocation. We then took each bees individually and pressed it on the gloves to make it sting. The bees then stung on the gloves. And thankfully the stings did not reach the other side of the fabric proving that the fabric thickness is just a bit too thick for the stings to reach the other side and penetrate the skin.

Making and testing the final suit

d. mock-up testing

Making and testing the final suit

d. Mock-up testing

To try and quantify the humidity and ventilation factor of the suit, the relative humidity was measured using a hygrometer. The Hygrometer was kept inside the existing suit and the gloves and the data was compared to the proposed fabric. The hygrometer was kept inside the suit and the gloves and the measurements were taken after doing some activities indoors and outdoors in the sunlight.

Measurements were taken at around 3-4pm in the afternoon. The Ideal humidity is about 60% indoors and 45% outdoors. The Humidity of Mumbai weather was measured in about 62% indoors and 41% outdoors. Comparing the humidity of the existing suit to the proposed fabric, there was a difference of about 10% indoors and about 5% outdoors.

Humidity	Indoor	Outdoor
Ideal	60%	45%
Mumbai	62%	41%
Existing suit	75%	55%
Proposed fabric	65%	50%

Making and testing the final suit

e. Suit sizes

Part	Garment	Small (5'5")	Medium (5'7"	Large (5'9")
Upper	Chest circumference	36"	40"	44"
	Wrist	7.5"	8"	8.5"
	Waist	30"	34"	38"
	Shirt Length	27"	29"	31"
	Neck	15"	15.5"	16"
	Shoulder	16.75"	17.25"	17.75"
	Sleeve length	22"	24"	26"
	Shoulder to waist	18.5"	19.5"	20.5"
Lower	Hip	38"	42"	46"
	Crotch depth	10.5"	12.5"	14.5"
	Pant length (waist to heel)	40"	42"	44"
	Waist to knee	18"	19"	20"
Gloves	Wrist	8"		
	Forearm	9"		
	Wrist to Forearm	8"		
	Index to Wrist	7"		
	Middle to Wrist	7.5"		
	Little to Wrist	5.5"		
	Length of Thumb	3.25"		
	Palm length	4"		
	Palm width	4"		
Head Veil	Forehead	22"		
	Head to Chin	7.5"		
	Neck	15.5"		
	Ear to Ear	13"		
Foot	Calf	11"		
	Ankle	9.5"		
	Calf to Heel	8"		
	Calf to Ankle	6"		
	Heel to Big toe	9.5"		
	Foot Width	5.5"		

http://mgiri.org/wp-content/uploads/2014/05/Development_of_Protective_Clothing_for_the_Indian_Beekeeper.pdf

Making and testing the final suit

f. Costing

Cost is one of the major factor of the project. The Final product either has to cost the same or lesser than the cost of making the current suit. The suit has to be design in such a way where it has less stitching subsequently reducing the stitching cost. After all these works, if the products much more than the current one, the honey hunters especially the ones whose livelihood depends on this would be better off with the current suit. On top of providing all the advancements to the current suit by design and as well as the material the end product surely must cost less.

The existing suit costs about ₹2200 total. The material cost is about ₹1000 for the material and about ₹1200 for the stitching. The total amount of material used in the suit is about 6m2.

The proposed suit we would use about 4m2 of the material which costs about ₹160/m. For 4m2, it would cost about ₹640 and for stitching say ₹1200 and the total cost would be around ₹1840. Which would mean the total cost is brought down to about 17% of the current suit. If the Material is brought directly from the factory and in bulk, we could reduce the cost by up to 20%.

As an end product the final suit after bringing all the advancements and addressing the issues, it would cost lesser than the current one.

Costing break-up

Fabric – ₹160/m
Stitching - ₹1200/suit
Total cost - ₹1840/suit approx.

The airmesh fabric from porwal group, Ichalkaranji -
- ₹450/kg (2.8m)
- 1m of the fabric is about ₹160

The suit needs about 4m of fabric which would be cost about ₹640

Stitching would cost about ₹1000 - ₹1200

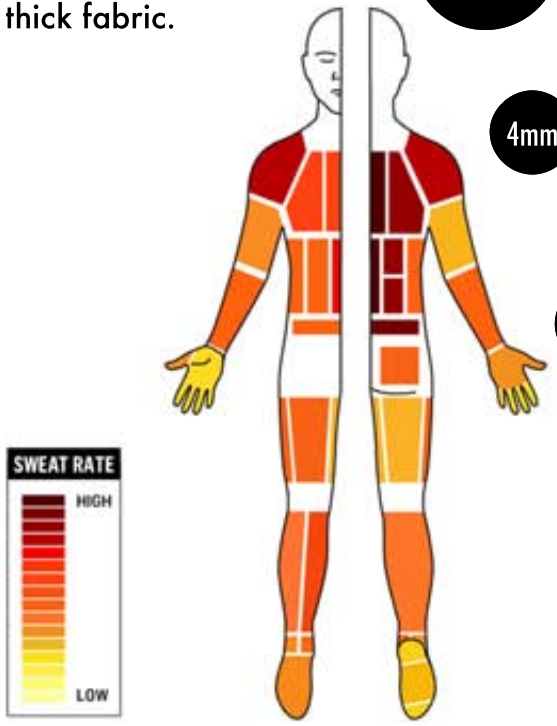
Assuming the stitching cost is ₹1200 the total cost is about ₹1840

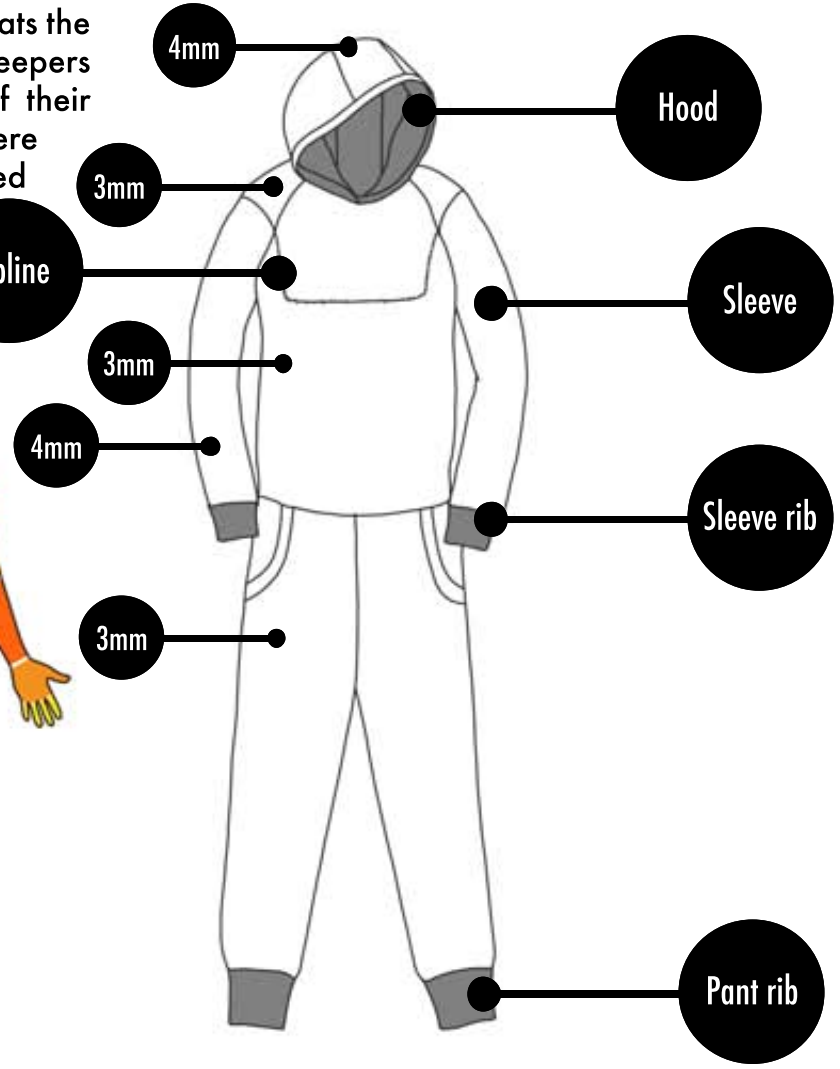
If the material is bought directly from industries in Delhi, the cost of each metre could be brought down to about ₹60/m. Considering the transportation cost, the fabric can be bought for about ₹100/m. The total cost of the fabric per suit would be around ₹400 and stitching ₹1200, the total cost of the suit could be brought down to about ₹1600 approx.

Making and testing the final suit

g. Final design

Pleaces in our body where it sweats the most are given below. The beekeepers usually wear the suit on top of their shirt and pant, so the places where it sweats the most can be covered with a thin while the rest of the places where it sweats less can be covered with a thick fabric.

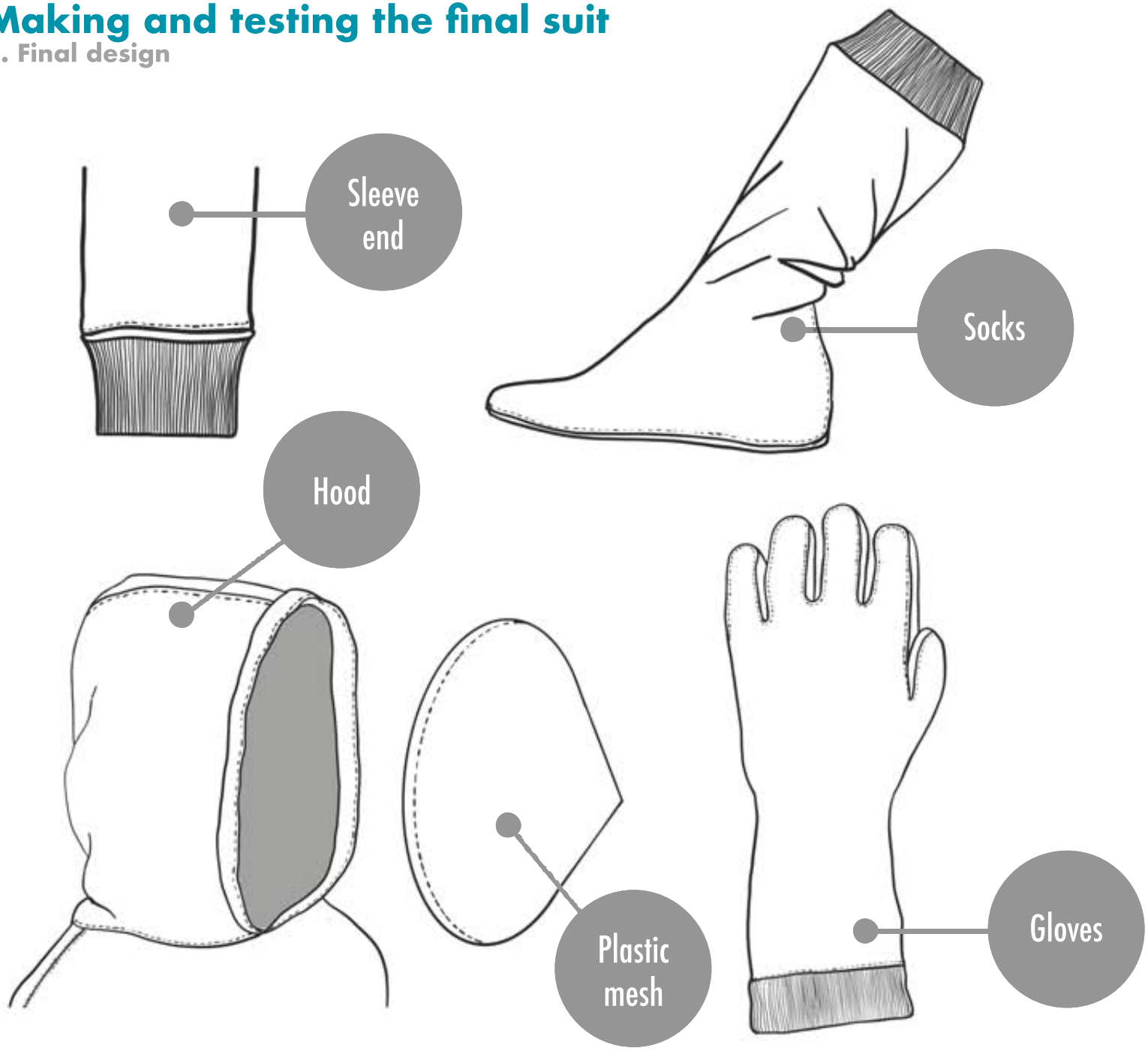




http://www.menshealth.com/sites/menshealth.com/files/wp_import/heat-map.gif

Making and testing the final suit

g. Final design



Making and testing the final suit

g. Final design mock-up


Thank you