
Sustainable
Honey Production

Sustainable Practices

The concept of sustainability is an umbrella approach that aims to meet human needs while reaching a balance between the ecological, social and economic components of a system; thereby, increasing the probability that products are adequate for consumption, environmentally acceptable, economically fair, socially just, with a stable production over time.

Production is aimed at generating quality products of family and local benefit and interest.

Products must be free of industrial and agricultural chemicals that may be harmful to human beings, plants and animals.

In this specific case, placing particular attention to the beekeeper, honey bees, beehive components and colony products: honey, pollen, wax, propolis, venom, royal jelly……

The money or equivalent obtained from the sale or exchange of such products must be adequate, so as to compensate for the expenses incurred in generating, processing, packing and selling or exchanging them.

On average, a differential must remain that increases the economic solvency of the family.

The resulting balance between these interacting factors should help increase the quality of life of the family and contribute to the wellbeing of the community.

This, in proportion to, but regardless of the enterprise's size or scale which could be any of the different categories between hobby and commercial.

This Sustainable Management Program for Honey Production, includes two sub-programs:

(1) *Colony Management*

(2) *Genetic Selection*

1. Colony Management

This subject addresses sustainable practices implemented while operating the colony of honey bees *Apis mellifera spp. (L.)*, that are under the direct influence of the beekeeper.

The principal goal for any beekeeper whether, hobby, semi-commercial or commercial, is to have the colony achieve a large population of foraging bees, so that it:

(a) collects the largest possible quantity of nectar and stores it as honey and

(b) performs as an effective pollinating unit.

This depends on the specific goals of the operation, but in many ways both goals are similar, in terms of how to develop and maintain a large foraging population.

The main difference arises when internal space is increased to accommodate honey storage, space increase not required in pollinating units.

To consistently generate a rewarding honey harvest the beekeeper must

clearly visualize **and**

effectively manage

those components that impact most significantly the expansion of the population of honey bees in the colony.

The number and magnitude of interactions between colony, environment and beekeeper are many and highly variable.

We will consider those that are under beekeeper's control in relation to the colony's *population development* and *health*.

These Management Practices are divided into four concrete subject areas;

(a) *Comb Quality*

(b) Internal Volume of the Beehive

(c) Age of the Queen

(d) Genetic Characteristics of the Queen

1. Comb Quality

Comb quality is a primary factor to incorporate into a successful colony management program and it is 100% under beekeeper influence.

Granted, the bees are the ones that build the comb, but the beekeeper decides if it is removed or not from the beehive.

A colony must have a large forager population to be able to store an average and above quantity of honey.

For that to happen the colony requires a large number of worker cells available to accommodate the egg laying of a good young prolific queen.

Any frame whose comb has less than 80% worker cells (of the total surface area) should be removed as it is reducing the number of cells available for the queen to lay worker eggs. Fewer worker eggs being laid means, less foragers in the field.

This also decreases the efficiency of the energy dynamics in the colony. Having a larger area producing fewer workers, increases energy (honey) consumption per unit area and colony.

Things that negatively impact worker cell surface area are:

-Drone cells

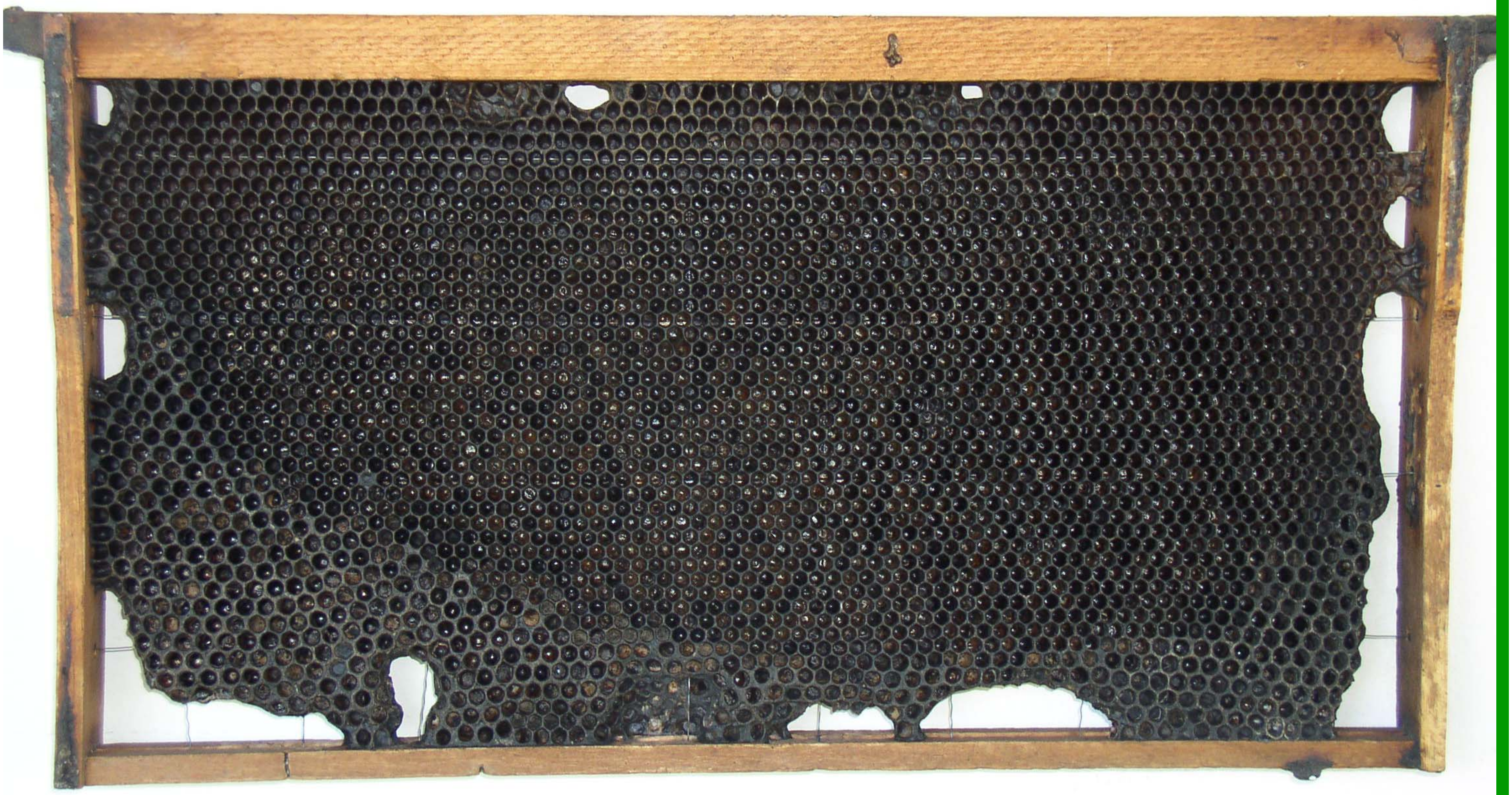
-Empty spaces

between frame and comb or within the comb area

-Transition cells

between worker and drone cells

Comb with a surface area roughly at 80% worker cell. Less than that and it should be removed.



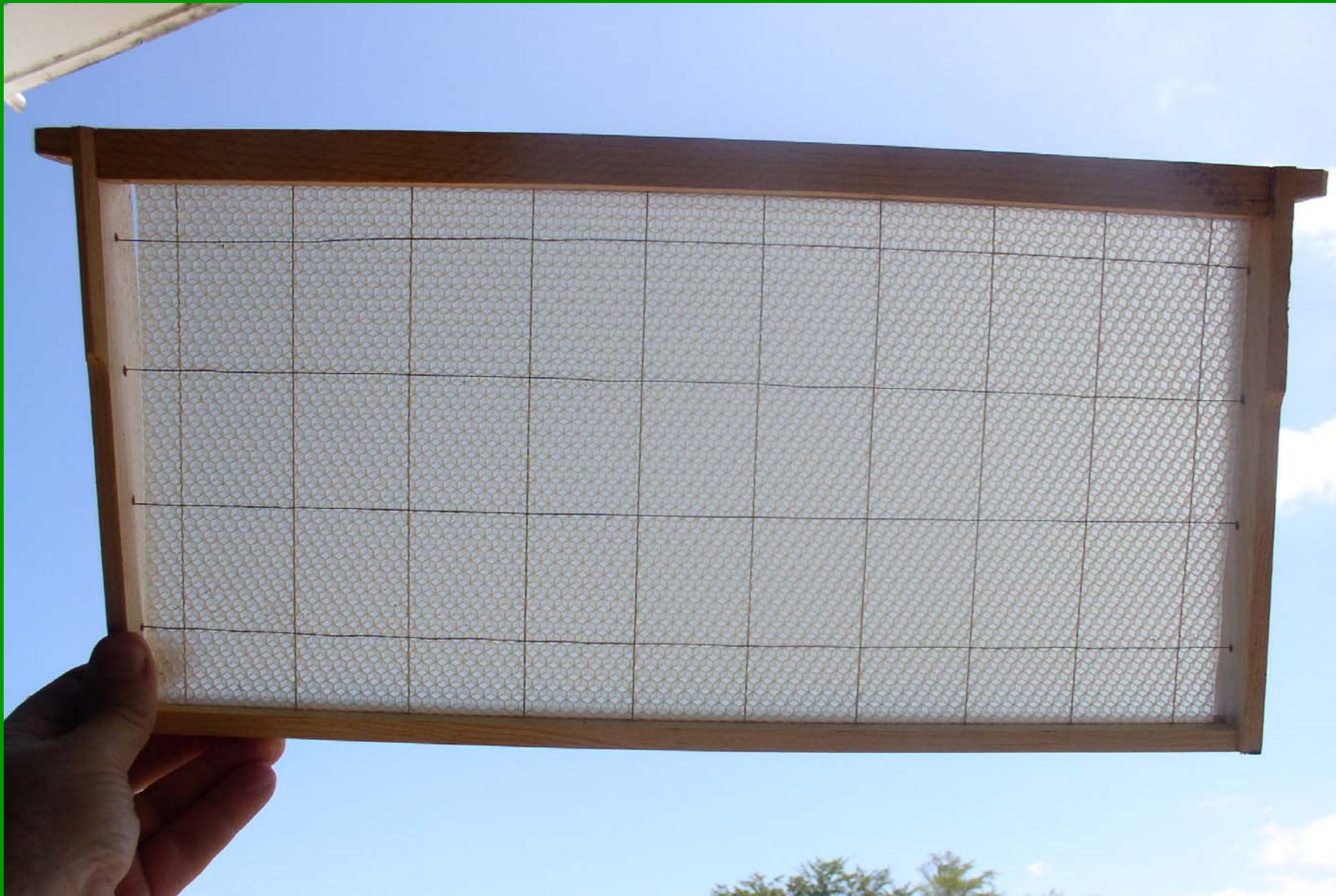
Good comb quality begins with careful frame assembly.

Glue all wood unions during assembly and use the correct nail size and quantity to obtain a strong frame.

The use of worker cell wax foundation significantly increases the chances of the bees building a larger number of worker cells per comb.

Eyelet and Wire Placement

Wire Strengthens the Comb



These wires provide additional strength to the mid-rib of the comb, making it less likely for the top lines of cells to become distorted after initial cell construction.

Once a worker cell’s shape is deformed, it will not be used by the queen to lay worker eggs. (All other parameters being acceptable, these combs may be used for honey storage.)

With increasing number of none-worker cells in the brood area, comb quality will become a limiting factor to the rate of expansion and eventual size of the foraging population.

Nowadays attention must be paid to the origin of commercial wax foundation, as it may contain questionable quantities of Fluvalinate (3.0-3.5 ppb) and Coumaphos (35-37 ppb)! (Used to control *Varroa* and other mites)

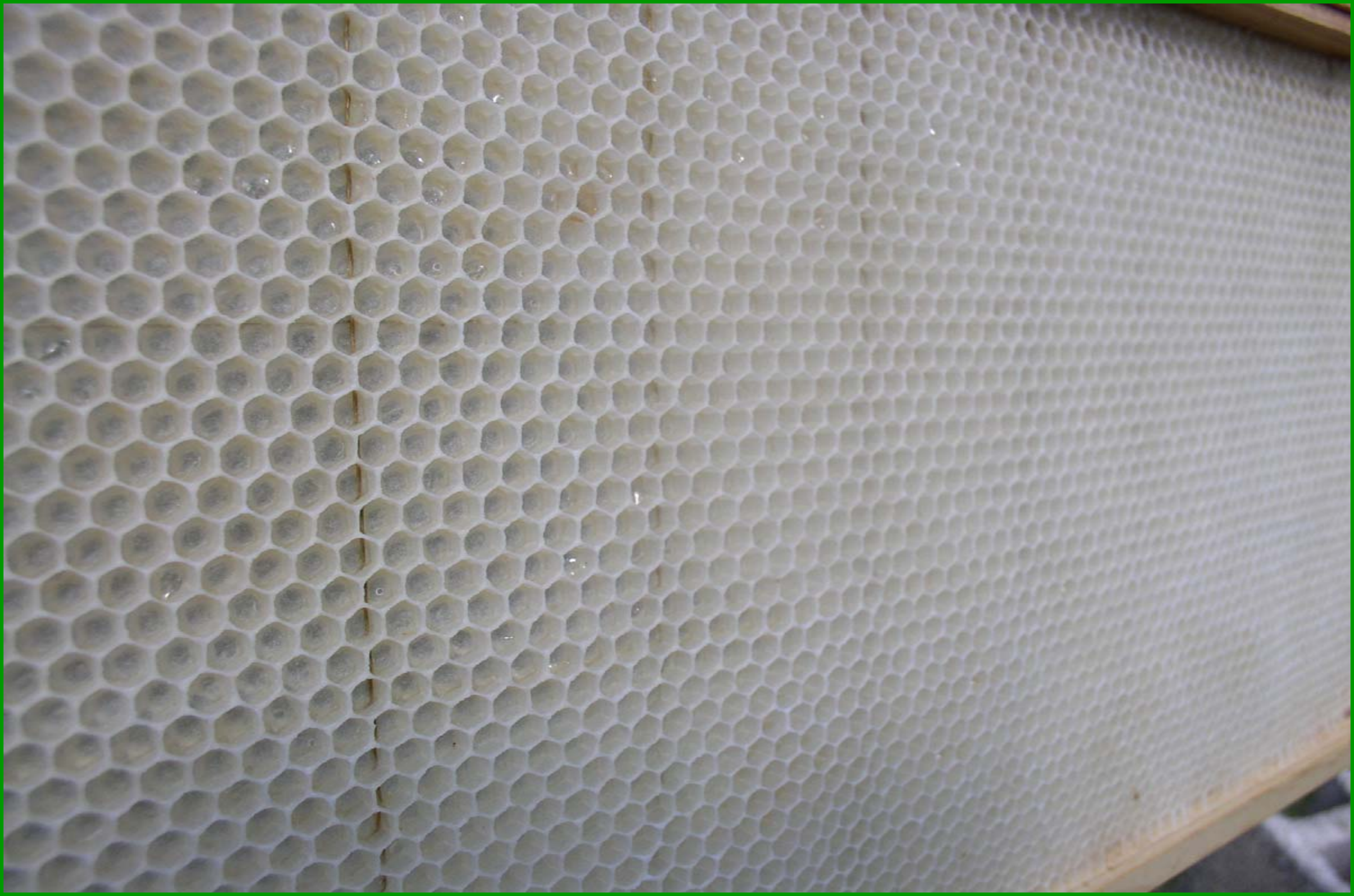
Significant efforts are being placed in removing Fluvalinate and Coumaphos from processed bees wax, but it is still not a reality.

An option is to make your own foundation – from wax obtained after bees build natural comb or ,

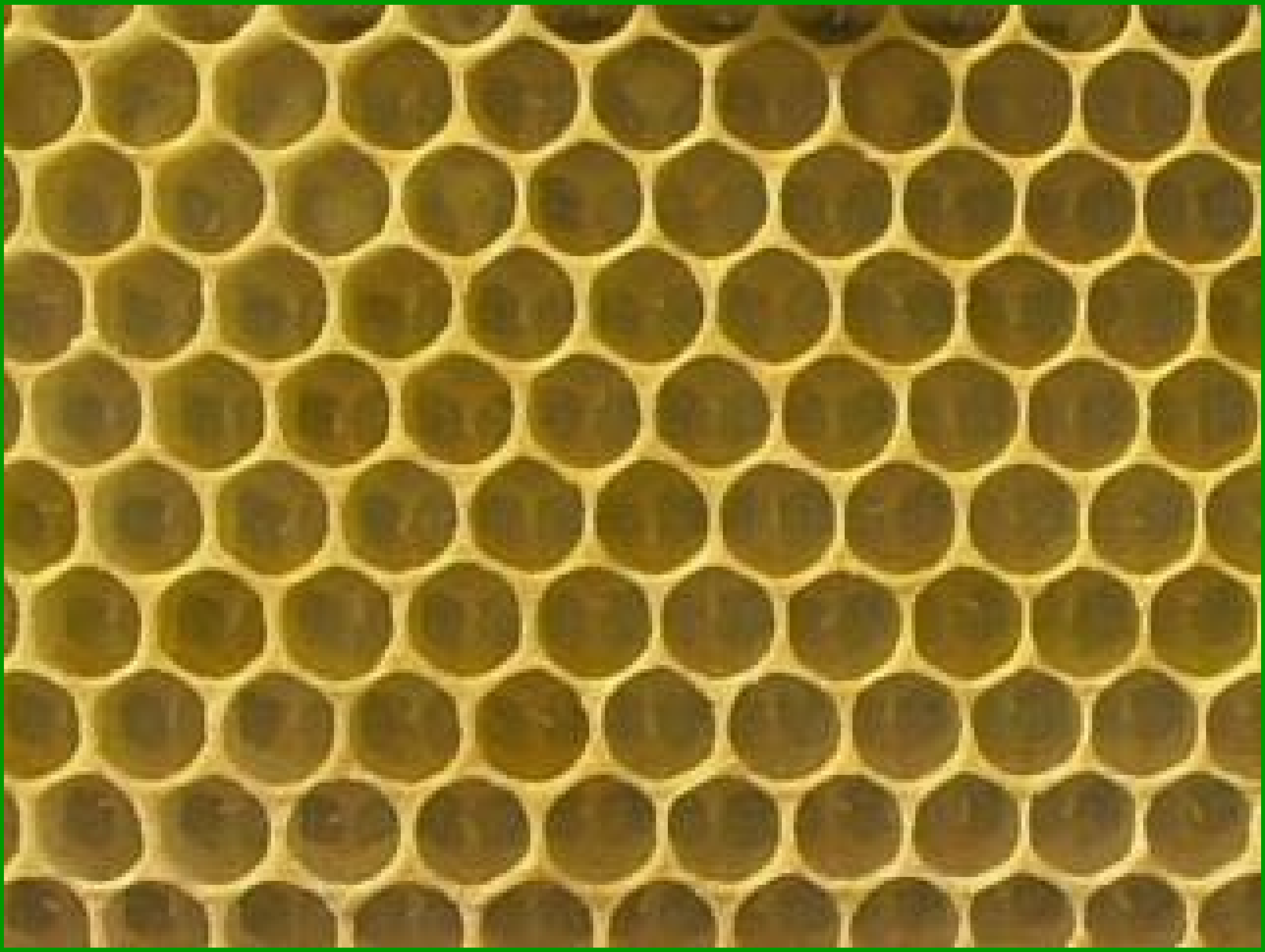
Allow the bees to build natural comb, and then remove those frames whose combs do not conform with the stipulated amount of 80% worker cell surface area.

Initiation of Comb Construction using Wax Foundation

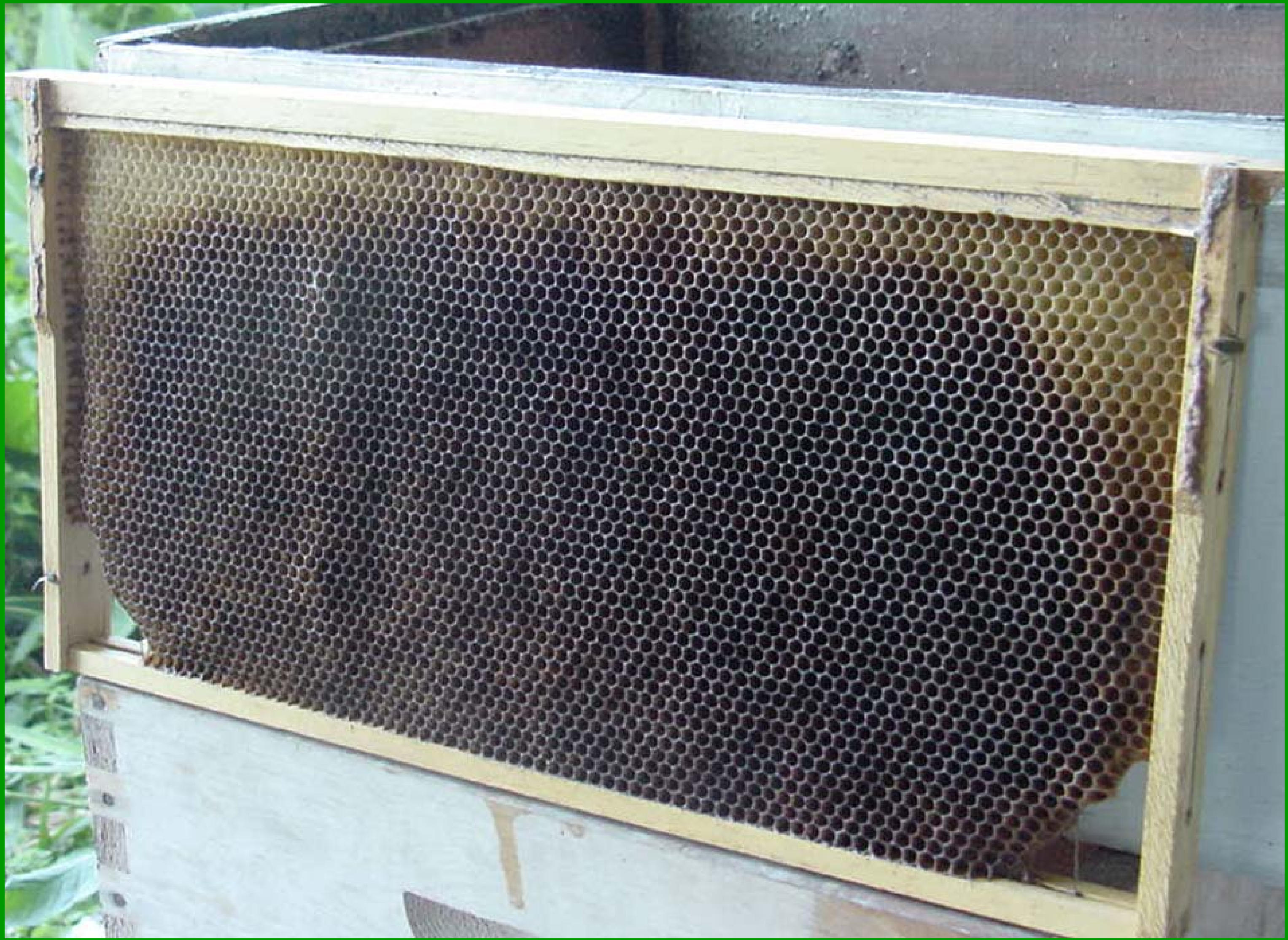
Highly Uniform Comb Construction



Large quantity and high quality worker cells



Comb with large surface area of worker cells



High % Worker Cell Surface Area being used by the Queen to lay Worker Eggs.

Combs in the brood area with at least 80% worker cells….

provide a larger area of worker brood rearing…………

……which leads to a high worker population.

Good comb quality leads to higher worker population; to a higher number of bees working inside the hive, constructing and maintaining combs, keeping hive surfaces and bees clean, but specially, it leads to more foragers collecting nectar and pollen.

That combination supports a higher probability of more honey being stored and harvested.

Colonies with high worker population practically take care of *themselves* and of *the honey harvest*.

A beekeeper must be observant of the hive's comb quality, to assist an increase in population development and honey storage.

Comb Full of Ripe Honey

Comb Full of Ripe Honey

2. Internal Volume of the Hive

The beehive's total internal volume is also an important factor to consider and manage, and it follows worker cell surface area availability, in importance.

If an adequate number of worker cells is successfully provided to the queen, a large worker population will be produced. Therefore, the need for the beekeeper to proportionally provide sufficient internal space in the beehive to:

(a) avoid congestion of the brood chamber

(b) diminish the probability of initiating swarming behavior and

(C) provide adequate space for nectar ripening and honey storage.

On average, this means providing the same amount of comb surface area for bee production, as for nectar handling and honey storage.

If there are 15 frames being used for egg laying, there should be 15 frames for honey storage, to provide adequate space for the bees to decongest the brood chambers, reduce swarming, and to ripen nectar and store honey.

The number of frames used per beehive for brood rearing vs. honey storage will depend on the ecosystem and bee type being used

This recommendation is the minimum proportion that should be provided to a honey producing colony in the tropics.

As a general rule, if a colony fills all available combs with honey, “honey was left in the field” and a larger number of frames should be made available to that colony.

The opposite is also true and if too much area is provided, the bees will increases energy consumption (honey). Plus, the added unnecessary expense and handling of beekeeping material.

This is why, keeping good records on honey production per colony and apiary, and experimenting with internal volume is important.

Providing the strongest colonies with some extra space is always a good practice to diminish swarming tendencies and increase honey storage.

3. Queen's Age

A factor of third level importance that may also significantly impact the amount of stored honey, is the age of the queen.

Queens, a year or younger, have the highest egg laying rates, as well as the highest levels of queen pheromone being produced.

A high egg laying rate by the queen is required to sustain a large number of worker bees.

The larger the population of worker bees, the higher the number and proportion of foragers bringing in nectar and storing it as honey.

Two colonies with 20 thousand workers will never store the same amount of honey as a single colony with 40 thousand bees.

Adequate levels of queen pheromone (oxodecenoic acid) have various important effects on honey bee behavior.

It increases the number of foraging flights , i.e. more nectar being brought in per unit time.

It supports wax production.

It provides cohesiveness among colony members, which increases efficiency, i.e. more energy is saved, which translates in less honey being used by the bees; therefore; more to be harvested by the beekeeper.

4. Queen’s Genetic Characteristics

Lastly, but no less important, consider the queen’s genetic characteristics.

The reason why this is considered as a fourth level factor is because the colony could be headed by a “high quality” queen, but older than a year and she will never build an adequate forager population to even make an average honey harvest.

Even if she is a year or younger, she will need to have an adequate number of combs with worker cells, and enough space to accommodate the developing population and store an average and above average honey harvest.

Otherwise, she will not be able to develop a high worker population, which will result in reduced honey storage when compared to colonies that meet the criteria being presented.

Another aspect to consider is that queens younger than a year exhibit the lowest levels of swarming behavior.

When does the Queen's Genetic Characteristics becomes an issue.

When within a group of colonies:

(a) there is too much variation in harvested honey weights impacting overall honey production goals,

(b) while queen age and

(c) colony management practices are being adequately addressed and

(d) historically the area has supported higher honey production.

2. Genetic Selection

The main objective behind initiating and maintaining a genetic selection program is to <u>increase</u> and <u>stabilize</u> honey production around values that are in tune with a goal that is realistic, lucrative and stable over time.

The program is based on the gradual but consistent *elimination* of genetic material that exhibits values that are *below the mean* for a group of colonies, for two behaviors.

It is achieved by producing new queens for all colonies, from genetic material *selected* at random from colonies that exhibit values from *above the mean* for those two behaviors.

The program contemplates selecting in favor of queens whose daughters exhibit above average values associated to two behaviors that may significantly impact colony performance:

(a) *honey storage behavior* and
(b) cell *hygienic behavior*.

Central to the overall strategy is what can be labeled as "*honey storage behavior* " of a colony, which has multiple heritable and therefore selectable behaviors that have the capacity to impact the amount of honey stored by a colony.

In a smaller and narrower, but equally important scale, the same may be said of the "cell *hygienic behavior*" expressed by the bees of a colony.

In this instance with respect to the effect of a specific cell cleaning behavior on the overall health of the colony.

By selecting and increasing the mechanisms which provide resistance to diseases and parasites, these, even when present, should not significantly adversely impact colony performance.

Healthier members, translate into a lower mortality rate, which support a larger population and a larger quantity of honey being stored per colony.

Moreover, if together with the increase in a health related behavior, we also select in favor of "honey storage behavior" we should further increase the probabilities of a group of colonies storing larger quantities of honey.

Specially when at the same time we are purposely eliminating genetic material that exhibits values from below the mean for both behaviors.

Hygienic Behavior Selection

Almost all events that have something to do with reproduction, development and storage of resources, take place in the basic structural unit of the comb, the cell.

In it, nectar is deposited, matured into honey, pollen is stored and bee bread is kept, an egg is deposited and a larva emerges which turns into a pupa and eventually into a worker, drone, or queen.

If a disease or parasite is found in a cell but not properly removed by the bees, the chances of it becoming a serious problem increase with time.

The sooner and more thorough the material is removed, better the chances of it not expanding and spreading to other cells and bees, and cause or increase bee mortality in that colony.

Hence, cell cleaning is a behavior exhibited by individual honey bees that may significantly impact colony performance.

Two behaviors associated with cell cleaning have been observed. Each one controlled by a different gen.

One is responsible for the removal of the cell cap.

The other is responsible for the removal of the contents of the cell, including cleaning and polishing cell walls.

As a result, each bee in a colony may exhibit one of these four possibilities;

(1) Neither of the two behaviors	***= 0 0***
(2) Cell cap removal	***= 1 0***
(3) Cell content removal	***= 0 1***
(4) Both behaviors; cell cap and cell content removal	***= 1 1***

In practical terms, colonies that have both behaviors being exhibited by the highest *proportion* of bees, will, on average, have less problems with diseases and pests.

If a health related condition appears, colonies with the highest proportion of bees exhibiting both behaviors will remove the source of the disease or pest sooner and more thoroughly, allowing the bees themselves to increase the probability of controlling the condition, preventing it from negatively impacting colony performance, its honey storage or pollination potential.

Another beneficial aspect of increased cell hygienic behavior is that as it increases, more individuals in the colony will do patrolling behavior throughout the colony's surfaces, which also supports an increase in overall colony hygiene.

A more hygienic colony should have a larger population due to a reduction in bee mortality. This also increases the probabilities of increased honey storage.

Aim to eventually reach and maintain in the population a cell hygienic value of 0.80_{24}.

This means that on average the colonies in an apiary remove 80% of the dead pupa from the test in 24 hours or less.

Procedure

To successfully implement a genetic selection program we need to:

(a) *identify each colony*

(b) quantify and record the cell hygienic behavior value for each colony

(c) sort from high to low all evaluated colonies based on the numerical value of cell hygienic behavior.

(d) calculate the numerical average for all recorded values of hygienic behavior.

(e) identify colonies with values above the average for hygienic behavior.

(f) *randomly select a number of these colonies. Depending on total number of colonies being evaluated, this usually represents, 10-20%*

(g) use larvae from these selected colonies to produce queens for all colonies in the apiary.

(h) Drones may be produced from part of these colonies to increase the probabilities of virgin queens mating with the desired lineage.

Example of a Colony Identification System, for a colony with four chambers in an apiary named Alzamora

FA-5(b) = 2nd Super - Hive 5 - Alzamora

FA-5(a) = 1rst Super - Hive 5 - Alzamora

FA-5(2) = 2nd Brood Chamber - Hive 5 - Alzamora

FA-5(1) = 1rst Brood Chamber - Hive 5 - Alzamora

A metal or plastic tag may be placed on a pre-determined area of each of the four chambers to identify that chamber, making it easy to identify it even when the chamber is not on the colony, like during honey extraction.

Increasing Cell Hygienic Behavior for a Group of Colonies

- This test should be performed on full sized colonies, i.e. ready for honey production.
- Performing the test on similar sized colonies is required so that test conditions are uniform and comparable.
- It is not the same thing to introduce comb with ≈131 dead pupae to be removed by a colony with 15-20,000 bees as in one with 35-40,000 bees.

Place a thin plate with an internal rectangle, (or parallelogram with equal area), with an internal area of 32 cm^2 (4 x 8 cm) over a comb with an ample amount of worker pupae.

There should be no more than 10 empty cells in this area.

Example of a Plate used to Measure Cell Hygienic Behavior.

Introduce a pin on each of the four internal corners to delineate the test area, and to be able to return and place the plate over the exact same area after 24-48 hours.

To obtain the first reading = C_1, count the number of capped cells (pupae) in that 32 cm^2 area with capacity for ≈ 131 cells. Record the number of pupa in that area, for that colony.

With a fine pin or needle, pierce the capping, go all the way to the bottom to kill that pupa, being careful to make the smallest hole possible in the capping.

Repeat the procedure for each capped cell (pupae) within the test area.

The idea is to "simulate" a dead pupae from a disease or parasite and *activate the cell hygienic behavior*, if present.

Remove the plate (leave all 4 pins) and return the comb to the same colony, in a position 3 or 8 from a side, of the bottom brood chamber.

Wait 24 or 48 hours. After this time return to the same colony and place the plate over the same area of the first reading.

Count and record the total number of pupae left completely uncapped = C_2 .

To calculate Cell Hygienic value for that colony use the following formula:

$$CH = (C_1 - C_2)/C_1$$

The average Cell Hygienic value for a group of colonies is the sum total of all the individual values, divided by the total number of colonies.

The Cell Hygienic value for a colony will be between 0 & 1. As it tends towards 1, more hygienic are the bees in that colony.

The goal of the test is for the bees to detect and remove the dead pupa.

The sooner they detect and remove the possible “threat” to the colony, lower the probability that the disease or parasite will become a significant problem.

An important component of this colony response is the amount of threat removal per unit time.

Depending on the degree of previous exposure and selection to diseases and parasites, initially the tests should be performed with a waiting period between C_1 and C_2 of 48 hours.

When 10% or more of the colonies remove 100% of the dead pupae in 48 hours, the waiting period is shortened to 24 hours.

Aim to obtain and maintain an average Cell Hygienic value among the colonies of 0.80 in 24 hours = average for the apiary.

The information is easier to handle if a worksheet or spreadsheet is used (Excel), as it can be made to summarize and provide the necessary values at a glance.

The headings; colony, date, apiary, values for C_1 and C_2 are entered. Other values are then calculated incorporating simple mathematical formulas that compute the hygienic value for each tested colony, the mathematical mean for that set of colonies, and colonies above and blow that mean. (Sample worksheets - available upon request)

Using the options provided by the worksheet’s program, you can perform data sorting which allow displaying the values from higher to lower.

You can also calculate the number and percent colonies above and below the mean for each behavior and even the standard deviation from that mean, which will provide information as to how uniform or not are the colony’s response with respect to the mean cell hygienic behavior of that group.

	Colony Id.	SEALED @ 0-HRS	SEALED @ 24 HRS	# Cleaned Cells	Cell Hygienic Value	Above Average	Below Average	% Up or Below The Avg
1	#5-98	112	0	112	1.00	1		8.71
2	#18	124	0	124	1.00	1		8.71
3	#8-98	122	0	122	1.00	1		8.71
4	#10-98?	120	1	119	0.99	1		7.80
5	#7-98	114	2	112	0.98	1		6.80
6	n-9	96	2	94	0.98	1		6.44
7	N-2	119	3	116	0.97	1		5.97
8	#11-98	118	3	115	0.97	1		5.94
9	#12-98	125	4	121	0.97	1		5.23
10	#4-98	97	7	90	0.93	1		0.86
11	#1-98	110	10	100	0.91		1	(1.18)
12	#3-98	122	12	110	0.90		1	(1.99)
13	#3-97	124	16	108	0.87		1	(5.32)
14	#1-97	122	17	105	0.86		1	(6.44)
15	#2-98	107	18	89	0.83		1	(9.58)
16	#11-97	119	28	91	0.76		1	(16.87)
17	#6	97	29	68	0.70		1	(23.79)

		Number of Colonies	17
Average Hygienic Value	**0.920**	Number Above the Mean	10
Standard Deviation--------	**0.022**	Number Below the Mean	7
Test Date________________________		% Above-----------------------------------	58.82
Test Time________________________		% Bellow----------------------------------	41.18

Using that information, select, at random, genetic material from colonies that have Cell Hygienic values on and above the mean, to produce queens *for all* colonies in the apiary.

Colonies being chosen for cell hygienic behavior are first selected for honey storage behavior.

On average, from one year to the next, average cell hygienic behavior values should increase, especially during the first three years. Variations between colonies in response to that behavior should decrease as well. This means higher and more uniform cell hygienic behavior values being exhibited among the colonies.

On occasions, factors other than those attributable to the bees, mainly environmental ones, make the value of a year be lower than the preceding one, when the opposite is what is expected.

Be mindful of this and keep accurate records. Be consistent in measuring and recording each observation.

Cell hygienic values should be recorded at least once a year for each colony, preferably before the strongest nectar flow, when colony expansion is the strongest. If measured more than once a year, use the mean for that colony.

By implementing this program the beekeeper has a relatively simple procedure that will help;

(1) *increase the cell hygienic behavior of a colony,*

(2) of the apiary or apiaries

(3) and reduce the variation in the expression of cell hygienic behavior between colonies,

(4) while maintaining a higher biodiversity in the gene pool of that population.

Achieving these four objectives should support an increase in honey being harvested by colony and apiary.

The bees response will also be more in tune with the specific conditions provided by that environment.

Remember that colony selection for cell hygienic behavior takes place after the colonies are selected for honey storage behavior.

Increasing Honey Storage Behavior for a Group of Colonies

One way of increasing the quantity of honey stored by a colony is to obtain the weight of the honey harvested from each colony of each apiary (all other practices being properly managed), and produce queens for all colonies from colonies with honey weights on and above the mean.

When genetic material that on average has honey weight values higher than the mean is used to produce queens for all the colonies, a conscious selection is being made for genetic material;

(a) that was able to increase the population,

(b) in synchrony with the nectar flow, and

(c) effectively managed diseases and parasites.

That is why selecting for stored honey weight is primary to cell hygienic behavior and should be performed first.

Just as it was done to calculate cell hygienic values, the beekeeper must keep good detailed records of honey weight :

(a) from each colony,

(b) for each apiary

(c) for each harvest

Procedure:

-Weight the honey chamber or super right before the honey is extracted or centrifuged.

-Record that $weight_1$.

-Extract the honey from the combs, place the empty combs back in the super and

-Record that $weight_2$.

The difference between the two weight readings is the amount (weight) of honey stored in that super.

Honey weights from supers belonging to the same colony are added together.

Repeat the process for each of the colonies in the apiary, for each apiary.

If there is a small number of colonies you may weight each frame with honey from each colony and add the weights, instead of removing the whole super.

It is a matter of preference, just be consistent over time so that results are comparable.

After obtaining the honey weight value for each colony, sort the values from highest to lowest, and calculate the mean weight for those colonies.

Use genetic material from above the mean to produce queens for all the colonies.

Slowly but steadily the number and proportion of colonies exhibiting higher honey weights will increase.

The largest increases will be observed during the first three years.

	Colony Id	Super Full-1	Super Full-2	Super Full-3	Super Empty-1	Super Empty-2	Super Empty-3	Total Weight	Galons		Abv. Avg	Bel. Avg
1	FA-21	45	27		12.5	12.5		47.00	4.00	95.16	1	
2	FA-14	43	22	16	12.5	12.5	12.5	43.50	3.70	80.62	1	
3	FA-2	39	25		12.5	12.5		39.00	3.32	61.94	1	
4	FA-9	36	15		12.5	12.5		26.00	2.21	7.96	1	
5	FA-11	37			12.5			24.50	2.09	1.73	1	
6	FA-8	37			12.5			24.50	2.09	1.73	1	
7	FA-31	27	19		12.5	12.5		21.00	1.79	(12.80)		1
8	FA-49	32			12.5			19.50	1.66	(19.03)		1
9	FA-25	29			12.5			16.50	1.40	(31.49)		1
10	FA-9	24			12.5			11.50	0.98	(52.25)		1
11	FA-6	21			12.5			8.50	0.72	(64.71)		1
12	FA-13	20			12.5			7.50	0.64	(68.86)		1
13												
14												
15												
					Number of Colonies being tested---							**12**
					Average Weight			***24.08***				
					Average Galons				**2.05**			
					Standard Deviation (STD)			***13.12***	**1.12**			
					Above Average					**6**		
					Below Average					**6**		

How to Combine Both Values

Once both values, honey storage and cell hygienic behavior have been generated;

(1) *Select, at random, a representative number of colonies (usually 10-20%) from the total number of colonies being tested, which have <u>honey weight</u> values above the mean,*

(2) ***from these, now choose those that have values on and above the mean for <u>hygienic behavior</u>***

(3) ***half of these colonies will be used to obtain larvae to produce queens and the other half will be used to produce drones.*** **(By purposely placing drone comb in these!)**

Next year repeat the procedure again

During the first three or four years the increase will be significant for both behaviors. After which the now higher values will stabilize and fluctuate through time depending on factors like;

(a) *quality and consistency of the management practices*

(b) climate

(c) flowering intensity

This program works best for a project with a total colony number of 150 and above.

This will assure that there is enough genetic material and variability to minimize inbreeding problems.

Beekeepers with fewer numbers may join forces to generate their queens.

- Hobby beekeepers with few colonies (3-10), may benefit by eliminating those queens (and eventual queen cells) from colonies whose tested values are too low.
- A frame with larvae from a colony with a good combination of values for both behaviors may be used to produce a new queen for that colony.

If you have more than 20 but less than 150, colonies you may produce queens, using your preferred method, from as many different colonies as possible that have values on and above the average.

Summary

- To increase the amount of honey being stored by a colony, pay more attention to the quality of the combs, total internal volume of the beehive, and the age of the queen.
- You will be increasing the bees adaptability to the specific ecological conditions in that area, while increasing gene pool biodiversity for that population of colonies!

At the same time, establish a selection program that will slowly but steadily remove queens whose daughters generate honey yields below the apiary's average and replace those with queens that come from colonies that generate values from the mean and above for the combination of characters being selected.

In this way, you will slowly but steadily increase the number and more importantly, the proportion of colonies in an apiary that generate honey yields which will realistically meet production levels for that ecological area and bee type combination.

You will not be depending on selection parameters being chosen by others, which may be more applicable to other ecological areas.