Methods for Double Queening the Consolidated Brood Nest Hive[1]

The Fundamentals of Queen Introduction

Part I of a Two-Part Series

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INTRODUCTION

THE consolidated brood nest hive has two brood chambers separated by a single queen excluder with a queen in each chamber. There are two entrances which face in opposite directions (lower front and upper rear).

Brood is continuous throughout the two chambers. The brood nest is indistinguishable from that of a single queen occupying two brood chambers. Hence, the term *Consolidated Brood Nest (CBN),* Figure 1.

All bees have access to both queens and their brood, and to common supers above for storage of surplus honey. All of the nurse bees presumably participate in brood rearing and in the distribution of queen substances throughout the entire consolidated brood nest.

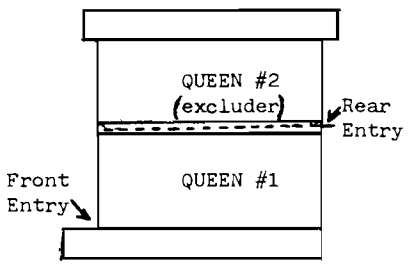

Figure 1: Consolidated Double Brood Nest Two Queen Hive.

The feasibility of double queening a CBN hive has already been demonstrated by the author.[1] It was also demonstrated that two queens, once established, are accepted by the bees and will coexist without fighting when separated only by a single queen excluder. The validity of these findings is supported by two further seasons of experiment and by the testimony of others in response to the original report.

If it is at all possible for a queen to kill another queen from the opposite side of an excluder (or screen), I believe it would be a very rare occurrence. In discussing hive manipulations where there appears to be a chance for two queens to approach one another, most writers continue to advocate the use of double excluders or double screens. This is unnecessary. The main problem in establishing two queens in the Consolidated Brood Nest hive is acceptance of the queens by the bees, just as in single queen introductions.

This is a report of further studies to develop methods and define limitations for introducing two queens into the Consolidated Brood Nest (CBN). The available literature on queen introduction[2,3,4,5] and those aspects of bee behavior [6,7,8] relating to queen introduction were first reviewed and analyzed. Specifically, the determinants of success or failure in queen introduction were sought.

Hopefully, this account will be of general value to the reader, as well as show how the solutions to CBN double queening were derived on a rational basis. The Consolidated Brood Nest (CBN) hive is presented as an alternative with significant potential for improvement over other two queen systems.

Analysis and Interpretation of The Determinants of Success or Failure in Queen Introduction

It seems that queen introduction fails either because the queen is destroyed by the bees or is superseded by the bees. Two theses for failed introductions, elaborated as follows, are developed throughout this discussion in relation to specific queen introduction principles and methods.

The first thesis is that: *The principal cause of the destruction of a new queen by the bees is worker aggression toward the new queen, either in response to defense alarm mechanisms or to queen stress (pheromone).*

Aggression by the workers toward a queen may be defense related or queen stress related, or both.

Defense related aggression could be precipitated by the foreign odor or the behavior of the new queen, or otherwise by anything foreign or considered to be a threat which is mistakenly attributed to the queen. Alarm pheromones[9] are secreted by the bees to communicate anything they perceive to be a threat. Two such pheromones are isopentyl acetate secreted from the base of the sting, and 2-heptanone from the mandibular gland. The pheromones stimulate alarm dances which recruit even more workers.

Queen stress related aggression by workers is thought to be triggered by a stress pheromone[10] secreted by the queen under stress. This putative queen stress pheromone comes from the queen whenever disturbed by mechanical means, by workers, or by the presence of another queen (or gyne).

Both alarm systems could function sequentially to compound the dilemma of a newly introduced queen, i.e. disturbances related to defense aggression could in turn stress the queen to secrete stress pheromone.

Since the new queen is usually balled instead of stung to death, it is possible that balling is a characteristic of stress pheromone aggression, while stinging is characteristic of defense re-

lated aggression.

The second thesis is that: *Once accepted by the bees, any new queen which does not promptly fulfill the colonies perceived needs for queen performance, as monitored by the levels of distributed queen substance, will be superseded.*

Queen substance,[11] produced in the mandibular glands of the queen, is known to be a mixture of *trans-9*-keto-2-decenoic acid and *trans-9*-hydroxy-2-decenoic acid. These substances are thought to be uniformly distributed among the bees through the food exchange network.[11] One of their functions is to suppress ovarian development in the female workers — assuring the supremacy of the queen. Prior to reaching levels inadequate to suppress worker ovary development, as with an aging queen, supersedure cells are started.

A newly introduced queen, failing for any reason to produce enough queen substance pheromone to restore the critical circulating level promptly, will be superseded.

* * *

Several general principles, which have now been established through time honored experience, guide most queen introduction practice. The premise is that the usefulness of each of the following eight (8) general principles can be attributed to its value in coping with one or both of the foregoing theses for failed introductions.

1) PRINCIPLE OF GYNELESSNESS: *Under normal conditions, a second queen will not be accepted by a hive that already has a queen (or gyne).*

The word gyne, as defined by Wilson,[12] is used throughout this discussion. "Gyne" is used for potential and actual queens inclusively. Although the word gyne is especially useful in representing potential queens (queen cells) or presumed queens (laying workers), "Queen" only is needed to represent functioning queens.

Generally no queen or gyne of any kind, including laying workers, should be present in a hive to be requeened. This is a prerequisite. The bees, perceiving themselves to be **gyneright** and the new queen as a foreigner, will quickly dispose of her. The term **gyneright** has broader implications than **queenright** because it also includes potential queens and laying workers. The presence of a queen is constantly signaled to the bees by a Putative Pheromone, called footprint pheromone,[11] secreted by the queen. Presumably even the presence of queen cells may be pheromone communicated.

One seeming exception to this principle is the atypical technique of Peer[13] for requeening without dequeening. In this procedure a ripe queen cell is inserted into a location remote from the brood nest of a queenright colony. The newly hatched virgin queen will be accepted if she gets to and destroys the unwary queen within that period of time (6-7 hours) when workers, and presumably queens, ignore virgins — possibly because the virgin has no odor to alarm the bees and is as yet unable to secrete stress pheromone.

Another apparent exception to this principle, mentioned by the Johannsons,[14] is that, when a "ripe" queen cell is present, the bees are more receptive to an introduced queen since the "appearance of the new queen fits the expectations of the colony." This suggests that it might be possible to except this rule if the apiarist were capable of reading and simulating colony expectations. While not practical for general requeening, this becomes a useful theoretical consideration in double queening (as will be seen later).

This principle does not say that two queens in a colony at one time are unacceptable to the bees. The many two-queen systems and reports of queens co-existing testify to the acceptability of two queens. A report attributed to Mr. Pritchard[15] states that "- - - if two queens having the same colony odor - - - are liberated - - - one in one corner of the hive and the other in the opposite corner, both will be tolerated by the bees - - - (and) both will continue to lay eggs in the same hive without interference if they can be kept apart by means of an excluder." Further, "this condition will be allowed so long as the colony prospers, or until a dearth of honey comes, when the bees show a disposition to rob. They will then destroy one of the queens."

The important question is when do two queens become unacceptable to the bees. If Mr. Pritchard's observation regarding destruction of one of the queens during a honey dearth is generally the case, this would be quite compatible with CBN double queening practice. Double queening would normally be done early during minor flows and terminated after the major flow. If the bees help out, that is fine. But it is my belief that as long as there is no significant **difference** in the performance of the two queens, at whatever level of egg laying, neither would be terminated by the bees even in a honey dearth: The hypothesis is that when two queens are of equal status neither of two queens will be selected over the other.

It has been proven that bees will in fact destroy supernumerary queens.[16] Multiple queens with blunted stings were introduced into a colony. Any losses had to be due to the action of bees. The interesting question is how they selected one queen over the other.

2) PRINCIPLE OF TIMING WITH THE HONEYFLOW: *During a honey flow almost any method of queen introduction will succeed.*

During a major honey flow the activity of the work force is pre-empted by foraging, nectar processing, and comb building for honey storage. Studies on the division of labor among bees of different ages reveal a remarkable **plasticity** of the work force.[17] This is the ability to shift from one activity to another as dictated by seasonally and environmentally induced needs. However, there is a general progression of the roles of any one worker with age.

A honey flow is a major event upon which the livelihood of the colony depends. In some regions survival of the colony depends entirely on a single honey flow per season. It is no wonder there is massive recruitment of the work force, *via* the complex communication system of bees, for foraging and related activities at the time of a major honey flow. Defense activity is almost entirely pre-empted.

The improved temperament of bees during a honeyflow is also due to this same phenomena of plasticity in which defense activity is shifted elsewhere.

The dramatic preoccupation of bees at the height of a honeyflow can be demonstrated by exchanging the queens of two hives when in full lay. Apparently their different colony odors go unnoticed, or a different colony odor is insufficient under the circumstances to trigger aggressive reaction toward queens when they show no stress. It is even possible that colony odors are much alike when both hives concentrate on a single source of nectar.

This general principle is of value as a guide to the **timing** of queen introduction, if one has that choice. In the case of CBN double queening, in this region, the ideal time would be in the first half of May during the fruit and dandelion flow in anticipation of the major flows six weeks later.

3) PRINCIPLE OF TIMING WITH TEMPERAMENT: *It is more difficult to introduce a queen to cross bees than to gentle bees.*

The phenomena of plasticity, just mentioned in connection with the honeyflow as favoring gentleness, manifests itself also to favor temperamental behavior. Certain environmental factors shift the priority of colony needs in the direction of defense. When the number of workers free for defense roles increases, the bees are more alert, so that newly introduced queens are at greater risk as intruders.

Among the factors causing bees to be cross are confinement, such as from inclement weather or a honey dearth — or threats, such as robbing by other bees or harassment by predators (skunks). Genetic disposition remains constant in a given colony, but accounts for differences between colonies in identical seasonal and environmental circumstances.

The usefulness of this general principle lies also in its value as a guide to timing i.e. **when not** to introduce a queen or to double queen, if there is a choice.

The above causes of temperamental behavior of bees are to be distinguished from inept handling of bees by the apiarist, such as rough handling, jarring, odors and quick movements. However, carelessness is more critical when bees are already alert.

4) PRINCIPLE OF DISRUPTING THE DEFENSE SYSTEM: *A queen may be introduced directly into a queenless colony after the defense alarm system has been disrupted.*

This principle is based on a strategy of overwhelming natural defense mechanisms, or manipulating the natural defense mechanisms, so that they are nonfunctional. This is in contrast to other strategies in which defense mechanisms are either bypassed, or accommodated.

One tactic is to impose contrived threats to pre-empt worker attention, such as vigorous drumming on the hive or heavy smoking; the bees rush to gorge themselves with honey for the emergency. In this condition their participation in defense response is cancelled. A queen may then be liberated among them.

More drastic, is demoralization of the bees by complete disruption of organization. Artificial shook swarming or shaking all bees outside the hive before liberating a new queen accomplishes this.

Another common tactic is to mask all alarm trigger odors and communication pheromones by overwhelming them with an all pervading, but non-offensive, fragrant substance (eucalyptus oil, peppermint etc. etc.).

This principle appears to have little value as a primary strategy for CBN double queening, as will be seen later.

5) PRINCIPLE OF COLONY ODOR EXCHANGE: *A new queen may be liberated in a queenless hive after it has been confined in that hive for 2-3 days, totally dependent on the queenless hive bees for food, in order to acquire the new colony odor.*

The rationale for this general principle is that the new queen will exchange her former colony odor for the odor of the new hive and thus become less conspicuous as an intruder. Colony odor is believed to be primarily characterized[18] by the aroma of a hives particular food mix and its nest odors. These are presumably absorbed onto the queens body, or are systemically acquired through the extensive food sharing network.

According to Wilson,[19] it may yet turn out that there is a genetic as well as an environmental component in colony odor.

This principle speaks to the most widely practiced of all queen introduction methods — the cage method. A plethora of cage designs have been described for accomplishing this, but they are not equivalent. The foregoing insight into the nature of colony odor is important to the selection of a cage and the detail of its use.

The cage should contain no food inside it from a previous source, and no attendant bees should be inside to feed her. In this way the queen must be fed by the bees of the hive, which quickly imparts to her the new colony odor.

The cage should also permit automatic release of the queen in 2-3 days, but preferably not through removal of a candy plug by the bees — since the same would be available to the queen as food. A cardboard barrier to be removed by the bees to release the queen is best. Also, in this way, there is no disturbance at the time of release to precipitate defense behavior — as there would be in manual release by the apiarist.

However, the rationale favoring use of the cage method is more complex than just stated. In addition to acquiring colony odor, the new queen's condition and equanimity improve, while the status quo regarding queen function and need for a queen change within the hive. These are compatible changes favoring the chance of acceptance of the new queen.

The cage method, when used under appropriate circumstances, as will be seen, is an important option for double queening the CBN hive.

6) PRINCIPLE OF QUEEN MATCHING: *Success is more likely if the condition of the new queen as to egg laying matches that of the queen to be replaced, so that the status quo with respect to queen function is maintained.*

Status quo may be defined as the prevailing state of the brood nest vs. queen function. Queen function includes, in addition to egg laying, the continuous communication of her presence and physiological activity. By introducing a new queen at the height of her egg laying, the status quo with respect to queen function within the hive is least likely to be interrupted.

Such a queen is more likely to fulfill other specific components of queen function, such as queen substance production, than one that has not been laying eggs; and she is more likely to present a state of equanimity so that stress induced aggression is avoided. But egg laying and behavior are the observable criteria by which the apiarist judges queen status.

The status quo with respect to queen function is constantly fluctuating as the bees and queen respond to seasonal and environmental influences *via* the complex communication network of the hive. It is useful to think of the bees as having "expectations" at any given time as set by the prevailing status quo within a seasonally balanced colony.

Replacement of their queen by another gives good cause for the bees to respond to the new queen as they would to any intruder, rather than as their sovereign — unless she behaves calmly and simulates reasonably well the preceding status quo. The poorer her performance (and condition) the more likely she will be at risk as an intruder. If she satisfies the prevailing colony expectations, she will be accepted.

If a queen is accepted, however, and then does not continuously exceed the minimum acceptable performance level, she will be superseded.

The principle of queen matching can be demonstrated by carefully substituting a new queen in full lay at the exact same spot from which the prevailing queen was just removed.[3] This is a dramatization and not a practical procedure.

This principle of queen matching has turned out to be the most important concept for adaptation to double queening the CBN hive. Initially the

status quo within each chamber of the CBN hive with its own queen might be sufficiently different so that expectations of the bees circulating from one of the chambers to the other are not met there. Such a concurrent differential in double queening could result in the destruction of the lower status queen. Principle 6 of matching queens should, by analogy, apply to double requeening. The difference is that the respective status quos are perceived concurrently instead of sequentially as in requeening.

7) PRINCIPLE OF THE COMB METHOD: *A new queen will be better accepted if accompanied by her own bees and brood on one or more combs.*

Simmins[20] in 1881 first described the "comb" method of queen introduction. A queen on a single frame with bees and brood was exchanged for a comb in the hive requiring a new queen. This was the forerunner of the NUC method of today in which 2-3 frames are used. According to Simmins, "- - - the plan was suggested - - - by the fact that two or more colonies could be safely united by intermixing their respective combs, while the bees remained clustering on them, when one queen left by the operator, would be accepted as sovereign of all."

The likely explanation for the success of this method is the prompt cancellation of the different colony odors due to the complete scrambling of the bees from both colonies. A new uniform colony odor arises *via* the food exchange process and the alternating placement of the combs from both colonies. The selected queen is accompanied by a large force of her own bees which share with her the previous colony odor. Even initially, before colony odor adjustment, the selected queen is inconspicuous as only one of a large force of bees which are "foreign" to the bees of the new hive. Colony odor as a basis for singling out the new queen is cancelled.

Considering that the queen in a NUC is also likely in full-lay (favorable, according to principle No. 6), it is no wonder that the "comb" method is regarded as the safest of all, especially when used during a flow (favorable according to principle No. 2). Presumably a queen in full-lay would also maintain an uninterrupted circulating level of queen substance.

The outdated practice of scrambling bees on comb, by interspersing frames from different hives to unite colonies, has interesting potential for double queening the CBN hive. It seems reasonable that both of the original queens would be accepted at once if the queens were placed on a frame in different chambers and separated by an excluder. However, in the event that the two queens were to be significantly apart in condition (status), the lesser would be at risk (principle No. 6).

8) PRINCIPLE OF EMERGING BEES OR QUEENS: *Young bees, just emerged, will accept any queen; virgin queens, just emerged, will be accepted by any bees.*

Very young bees apparently do not respond or contribute to defense alarm mechanisms. They will accept any queen.

Likewise, newly emerged virgin queens are ignored by bees for 6-8 hours. It is not clear whether this is because the virgin secretes a protective pheromone and is otherwise odorless or because she does not yet secrete any identifying pheromones e.g. queen stress pheromone.

These two circumstances permit the simple and safe practice of establishing small nucs for use in the comb method of introducing queens (principle No. 7), or the mating of virgin queens in commercial queen rearing.

The factors and interrelationships controlling the outcome of queen introduction as just discussed in this section are summed up and organized in the following chart. (Figure 2)

Part II of this two-part Series will discuss "Principles and Methods for Double Queening the CBN Hive." See the June **ABJ.**

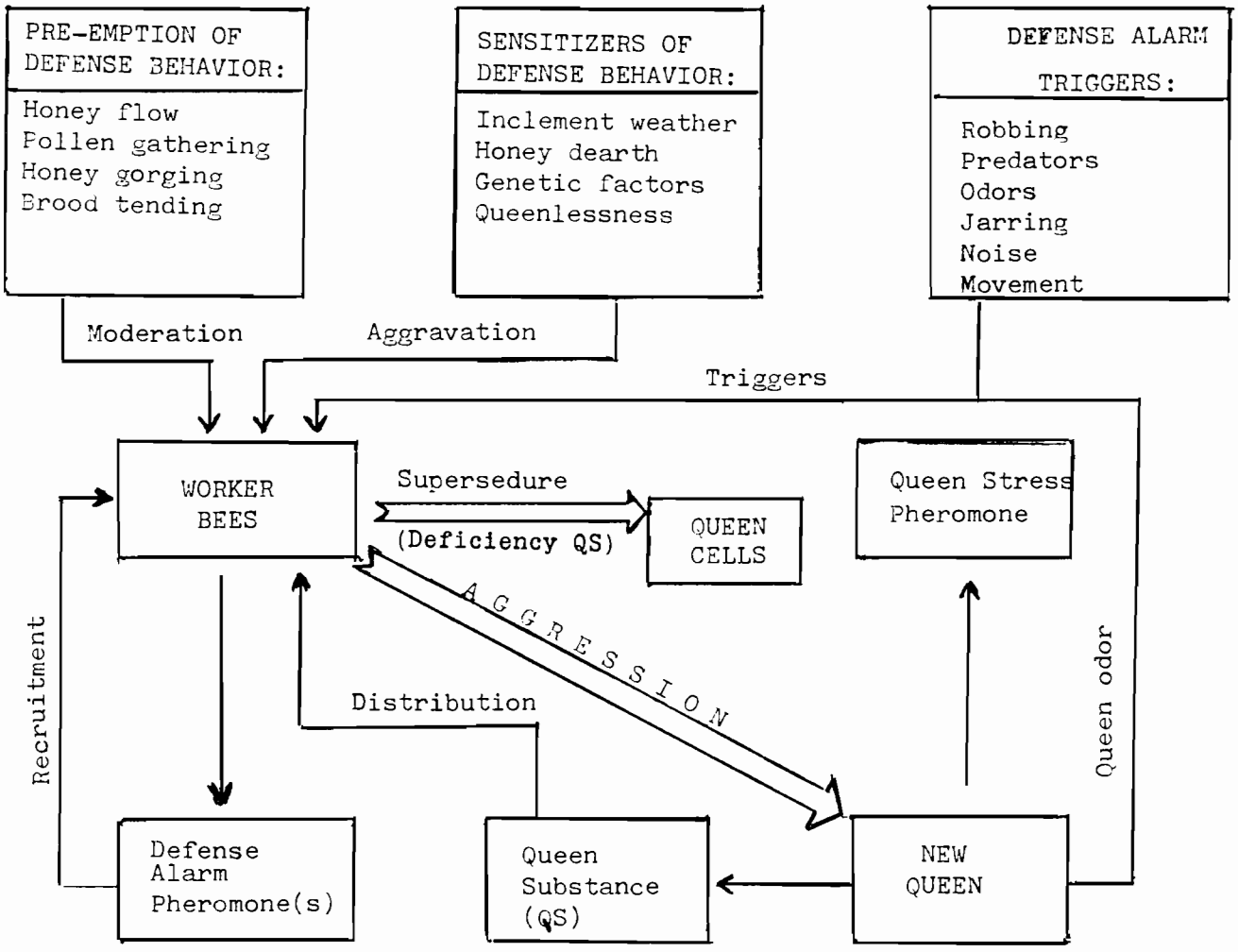

Figure 2: Factors affecting worker aggression toward a queen, or the supersedence of a queen.

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