Brood Rearing in the Winter Cluster

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Winter is an annual event, and the cold season will be here again before we know it. Wintering losses of honey bee colonies are becoming more frequent and serious now since varroa is infecting colonies worldwide. Beekeeping is in retreat, especially among amateurs and hobbyists.

And, we must admit that even a low level of infection in spring can have a disastrous effect on the colony towards the late summer. Following the first anti-varroa treatment in spring, a small number of surviving mites increases steadily throughout summer when no form of control can be administered effectively. When fall comes near, and bees prepare to face the coming winter by rearing a last batch of brood, maybe thousands of mother mites are entering the cells and they, and their progeny, will draw the life-blood of the very bees which should become winter-bees :

- the very bees pre-programmed to store additional reserves of protein and fats for winter - in order to become. . .
- the very bees which should survive the coldest part of winter in a partial dormancy, - and survive to be. . .
- the very bees which should rear the first batch of brood the following spring and carry on the species.

Autumn treatment against varroa, when all brood has emerged and after the honey harvest has been removed, may come too late; all emerging bees are damaged bees, are physiologically unfit to face the cold and are prone to disease. Many of them die, too early in life, thus weakening cluster strength and reducing its chances of survival.

In order to improve our colonies' chances of successful wintering, we must first learn all there is to learn about Varroa and its control. But we also must learn more about wintering and about the winter cluster. Of course, books are full of the traditional version, and the old recommendations also tell us that one should leave the wintering colonies alone, and never look into hives or interfere with the bees - or hives. But finding out how things work is an old human failing, and over the years beekeepers and scientists have poked mercury thermometers into the cluster, have gassed whole colonies before taking the hive apart and examining combs minutely. Recently, they also have taken the easy way out and have introduced lots of thermocouples into hives in order to take regular readings of the temperatures of the cluster and of its surroundings and have recorded them on a daily, hourly, or more frequent basis. The scientists then made their computers analyze the readings and produce pretty graphs and isothermal contour maps of the winter cluster - which they never saw! Pretty, but is that the whole story?

True, it is best to leave bees alone - once the colonies are well fed and safe from the wet and the driving snow. Yet in the 1950s, a Dr. Jeffree did try to discover what is going on in the winter cluster, and he examined about 360 colonies over a period of 10 years while he was at Aberdeen, Scotland. He tells us that it is all right to look into hives, provided the air temperatures rise high enough to permit cleansing flights and allow bees to return home safely afterwards (Jeffree, E.P. 1956). He discovered patches of brood at any time of the winter period, although the size and their occurrence appeared to increase towards spring. Furthermore, he could not relate their occurrence to climatic conditions affecting the whole of the apiary. Most hives were inspected once only in each winter, but among the seven colonies which he examined repeatedly - weather permitting - he found in two of them evidence of stops and starts of brood rearing.

All right, the winters in the north of Scotland can never match those of the northern states and of the Canadian provinces, but wintering in a cluster relies on inherited patterns of social (and individual) behavior which guarantees survival, and the basic principles reside in the genes of all bees of the European races of *Apis mellifera* L. Variations in temperatures are only a matter of degrees, not of principles. And, although the two winters were exceptional, sometimes the winters can also be bitter and prolonged in Scotland.

Dr. Jeffree's work, as well as that of many other scientists, was of great interest to me after I had discovered brood rearing in my hives in Lincolnshire one winter. Pondering over the reasons behind such an activity which, of course, could cost the lives of colonies through starvation or nosema disease, the search for an answer became a veritable compulsion. I took part in wintering surveys of food consumption, and was surprised at the variation in food consumption between colonies. After that, I started to examine my own colonies whenever I could. When

Col	09. 11. 74			29/30. 11. 74			28. 12. 74			30. 01. 75			18. 02. 75			Brood, Total	Food Cons.
	e	l	p	e	l	p	e	l	p	e	l	p	e	l	p		
1										/+	 /+	/+ /+	/+ +/	/+ +/	+/+ +/+	300	3.0
2		+/+	+/+				/+	/+	+/+	+/+ +/	+/+ +/	+/+ +/+	 +/+	 1/1 !	! +/+	1035	6.9
4										/+ +/+	+/+ +/+	+/+ +/+	+/+ +/+	+/+ +/+	+/+ +/+	1662	4.6
5				 +/+	 3/3		 +/+ +/+	 +/+ +/+	/+ +/+			! ! +/+ !	 +/+		! ! +/+ !	495	5.6
6			+/+ +/+	+/+ +/+	+/+ +/	/+ +/	 +/+ +/+	 +/+ +/+	+/+ +/+	 +/+	 +/+	+/+ +/+	 +/	 3/	! +/+ ! +/+ !	790	5.8
7							+/+	+/+				! /+ !	/+ +/	/3	! +/ !	300	3.4
8			+/+			!	+/		! +/+	/+	/+	/+	/+	/2	! +/+	147	3.0
9							/+	+/+	+/+	+/+	+/+	+/+			! +/+	312	3.7
11										 +/+	 +/+	+/+			! +/+ ! +/+	445	4.6
13				/+	/+	/+	 +/+	 +/+	+/+ +/	 +/+	 +/+	 +/+ +/	/+ +/+ +/+	/+ +/+	 +/+ +/+	1044	*
14				! ! !	 +/+	 +/+	! ! !		 +/+	! ! !	 +/+	+/+ +/+ +/	+/+ +/+	+/+ +/+	+/+ +/+	1228	7.0
15				/+	/+	+/+	+/+	+/+ +/+	+/+ +/+	! !	 +/	+/+ +/+	/+ +/	/+ +/+	+/+ +/+	1285	6.3
19	+/+					+/+ +/	+/	/+	/+ +/	! !		/+ +/+			! +/+ ! +/+	426	3.8
21							 +/+	 +/+	/+ +/+	+/+	+/+	+/+	+/+ +/+	+/+ +/+	 +/+	1710	7.8

* Super added, not in correlation

Table 1; Winter brood, 1974 / 75
(Area in cm² - Consumpt. in kg)

I was appointed to the Advisory Post at the College of Agriculture of the North of Scotland at Aberdeen, my investigations into the problem of brood rearing in the hive-locked winter cluster were intensified. During the first two winters, nearly all colonies in the Craibstone apiary (and my own) were subjected to regular inspections (weather permitting), and some of the colonies took part in other experiments which included the caging of queens (with access by workers), as well as the formation of 'super colonies' by uniting strong colonies to form one unit.

In this part we will first consider the work of the examinations, and the Tables 1 and 2 give a representation of my findings in the winters of 1974/75 and 1975/76. The two winters gave me numerous chances for examinations, with mild spells luckily occurring roughly (and randomly!) every three - four weeks. So as to avoid artificial engorgement, the hives were opened without smoke and the bees settled quickly without further aggression within minutes after closing up. Although it must be admitted that - possibly - more bees used the disturbance for a chance of an additional cleansing flight - and my protective clothing was needed for another protective reason!

Whenever a patch of brood was discovered, it was not only measured, but also minutely examined for the presence of eggs, larvae or pupae, and their presence was registered for every face of comb (Tables 1 and 2). Explanations for the study of the tables are: Each field is divided into three: eggs, larvae, pupae; as indicated below the date (e; l; p). Each line corresponds to one frame, and a slash (/) represents the mid-rib of that comb. A plus sign (+/+) on both sides of the slash means that eggs, larvae or pupae were present on both faces. Sometimes one look was enough to see that the older, larger larvae were missing, and so particular attention was paid to any irregularity in the pattern of larval age. Whenever only eggs - and no larvae - were found, or at other times only one-day, two-day or three-day-old larvae were seen in the depth of cells, this was recorded separately. This is represented as a figure 1, 2, or 3 instead of the plus sign which indicates the presence of larvae of all ages.

Of course, beekeepers immediately recognize that here the queen had stopped laying for a while and that she had just started again after a **'brood stop'** had occurred. Some colonies showed two or three of these stops, and they are identified with exclamation marks in the appropriate column. In one colony the few remaining capped cells looked suspicious and their contents were removed. They were dead, fully developed pupae, but the imagoes looked shrivelled. They were mummies only and showed no sign of AFB or EFB. An asterisk, (/*) not a cross, indicates these findings.

The tables show that some brood could be found in some colonies during any of the winter months; even November and December were not without such activity. True, the number of colonies starting to rear brood and the size of the brood patches increased towards the end of the winter period. But the number of brood stops (and starts) also became more numerous towards spring.

The sum of the brood areas discovered (in centimeters, and not adjusted to account for longer of intervals between inspections), is recorded at the right of the tables, and it shows wide variation from 147 cm² to 2730 cm²- all in the same apiary. Allowing for a cell density of 4 worker cells to the cm², the number of bees born during 'dormancy' ranged from a low 588 to 10,920 bees. The last figure represents a veritable and generous 2 lb. package!

The patterns of egg laying also are of passing interest. In some colonies the small patches of brood were on opposite faces of adjacent combs - and the queen did not have to leave the center of the cluster, while in Col. 2 (Table 2) the queen had to move over into the neighboring passage to lay her eggs on the other face of the same frame—a colony with too small a cluster to support a larger brood nest? No, a spring examination showed that the two colonies were firing on all cylinders once March had arrived and some foraging activity had recommenced.

Only one queen died during the winter examinations of normal colonies (Col. No. 24; Table 2). We have always been warned about the danger that bees may 'ball' their queens when interfering at wrong times, but the records show that in this case pupae were still emerging 30 days after the last inspection. This implies that eggs were laid for at least one more week after the last examination, and that the queen must have died from 'natural causes', maybe old age.

It is just these details of the careful inspections which made the work so important. Although brood rearing in winter has been known to occur for a long time, sometimes by accident, no other work has supplied the clear evidence that

Col	05. 11. 75 e l p	01. 12. 75 e l p	28. 12. 75 e l p	17. 01. 76 e l p	15. 02. 76 e l p	Brood Total	Food Cons.
2			/+ /+ /+ +/ +/ +/	/+ ! +/+ +/ !	/+ /+ +/ /+ +/+	595	4.1
3	/+		+/+ +/+ +/+	+/+ +/+ +/+	/+ /+ /+ +/+ +/+ +/+ +/ +/	620	4.6
4	+/+ +/+ +/+ +/ +/+		+/+ +/+ +/+ +/+	! +/+ ! */*	! +/ ! /*	1042	4.2
6	+/+ +/+ +/+		! +/+	+/+ 3/2 ! +/+	+/+ /+ /+ +/+ +/+ +/+	839	5.0
7			+/+ +/+ +/+ +/+ +/+ +/+ +/ +/	+/+ 3/3 ! +/+ +/+ 3/3 ! +/+ +/ 3/ ! +/+	/+ +/+ +/+ +/ +/ +/	820	4.9
8				! +/+ ! +/	+/+ /+ +/+ +/+ +/ +/+	172	3.8
9				! +/+ +/+ ! +/+	/+ ! /+ +/+ 3/3 ! +/+	213	3.4
13	/+ +/+ +/+ +/+ +/+	+/+ +/+ +/+	+/+ +/+ +/+ +/+ +/+ +/+ +/ +/ +/	+/+ +/+ +/+ +/+ +/+ +/+ +/+ +/+ +/+	+/+ +/+ ! +/+ +/+ ! !	2730	9.5
18				+/+ +/+ +/+ +/+ +/+ +/+ +/	+/+ ! +/+ +/ ! +/+ !	315	4.0
20					+/+ /+ +/+ +/ +/ +/+	165	4.1
21				+/+ 2/2 ! !	+/+ /+ +/+ +/ +/ +/+	283	3.9
24			+/+ +/+ +/+	+/+ +/+ +/+	Q* +/+	595	*(5.7)
25				/+ +/+ +/+ +/+ +/+ +/+ +/+ +/ +/ +/	+/+ /+ +/+ +/+ +/+ +/+ +/+ +/+ +/+	1312	8.0
26					+/+ +/+ +/+ +/+ +/+	189	3.7

Table 2; Winter Brood, 1975 / 76 (reduced)
(Area in cm^2 - Consumpt. in kg)

* Q. died; not in Correlation

brood stops and starts occur so frequently and are probably an important part of winter brooding. Even hundreds of thermocouples registering every five minutes cannot show up the cessation of egg laying - nor its re-initiation. After all, brood rearing is an on-going process and lasts three weeks (possibly longer in a winter cluster!), so brood nest temperatures will be maintained at the high level of 35°C as long as living brood is present (unless brood dies for some reason). Yes, in later years we also did a lot of recording of hive and cluster temperatures, but that work never provided us with the same insight into cluster behavior as our direct inspections of winter clusters.

Yet it must be the initiation and cessation of egg laying by the queen which should provide a clue to brood rearing in mid-winter. Even among bees the old saying applies: "Every baby costs its mother a tooth." So we do need an explanation for the seemingly 'wasteful' production of energy-rich brood food and for the increased wear and tear this brings for the 'dormant' bees, but which are now sacrificing 'life and limb' - important protein reserves to raise young bees. Bees are thus laying themselves wide open to early death and nosema disease. Furthermore, we also need an explanation for the need of such 'wastefully' high cluster temperatures - which could lead to starvation of the colony as a whole.

The last sentence is not scaremongering. Hives had been weighed before winter started, just when flying had stopped. When milder weather and flight for water, for early pollen and nectar was becoming possible again on a regular basis, we called it quits and weighed all hives once more. A superficial examination of the listings showed a relationship, and when the sum of the brood areas and food consumption were statistically evaluated, a very high correlation: **$r = 0.92$** was obtained for the two winters and the 33 hives. Further statistical analysis even supplied the following regression equation :

Food consumption = 4.1818 kg + 0.000375 (kg) per cm^2 of brood.

Again, these values apply for the increase in food consumption - demanded by brood rearing over and above a basic minimum - only in the Craibstone apiary just outside Aberdeen over the two winters. But in principle they will stand for all true wintering in any climate. The results are so clear and significant - in spite of the individual patterns -and areas of brood rearing and the greatly varying food consumption, that we can say the following: **Wintering is a cluster-specific experience**, and any brood rearing in mid-winter costs additional energy over and above the basic energy requirements of a non-brooding colony.

Of course, we must never forget that winter brooding can also permit Varroa to 'rear brood' in mid-winter, and that many more young and strong Varroa mites will have a head start once brood rearing commences in earnest. So why do bees rear brood in mid-winter? How can we stop it? Furthermore: Should we try to prevent brood rearing - and how?

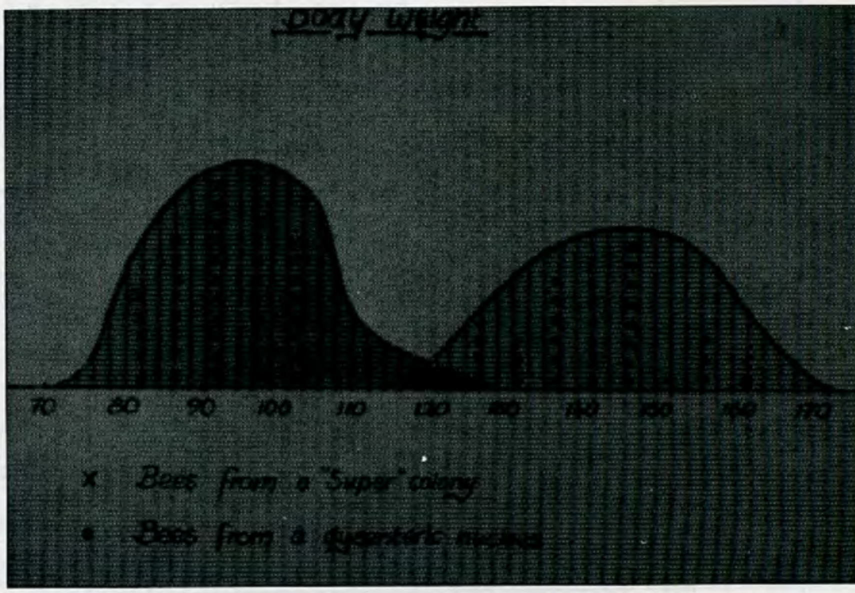
Well, some other experiments do seem to answer the questions, at least the last question. During both winters some queens were held in the center of the cluster in a small cage of excluder material in order to prevent them from laying eggs (while still giving bees ready access). Most of these colonies developed dysentery within three - four weeks and grew weak and weaker and hardly one stock in this group recovered when the queen was released in spring. In only one case did everything turn out all right afterwards. The queen was caged when brood rearing had started and before any cells had been sealed. When, six weeks later, signs of dysentery were seen, she was released from her prison. Four weeks later, at the first inspection of spring, there were 822 cm^2 (about 3250 cells) of brood on two frames - and no more dysentery. The records show the remark made at that time: "population greatly reduced". (None of these colonies appear in the tables, and none were included in the calculations of statistical analysis.). So it seems that - sometimes - NOT rearing brood is even more stressful than doing so!

'Super colonies' were created during the second winter period. Such colonies never reared any brood. They had been formed as an additional experiment after reading Dr. Jeffree's other paper in which he disproved the age-old advice that "the best packing for bees are more bees". He had found in his work on the influence of colony size on the rate of population losses, that the weak stocks, as well as the very strong colonies, lost more bees than what he called 'normal-sized' colonies. It was for that reason that I decided to sacrifice four strong stocks in autumn and to unite, in each case, two of them by the newspaper method after removing one queen. In both cases uniting went off peaceably, and all seemed well. Bees were frequently flying from these 'super colonies' and their flight was fast and direct - not to rob a weak stock, but to a source of water.

After a longer spell of cold, the weather relented again to permit cleansing flights - and inspections. Both 'super colonies' had massive, disastrous losses, and bees were clinging to the hive sides, to hive stands, to grass blades as if the 'Isle of Wight' disease (tracheal mites) had struck another blow. But trachea were clean and healthy, and no Nosema was found. Bee samples taken came to life again once they were in the warmth of the laboratory. With an idea forming in one's mind, the bodies were then weighed individually before bowels and honey stomach (with contents) were removed for further investigation. These produced the following results, when compared with samples taken from standard and dysenteric colonies (in that order). (See Table 3)

The bees from the 'super colonies' had no excuse to fly on a cleansing flight, their stomachs were just about empty. The low (empty) body weight shows that blood quantity was low and it was extremely difficult to obtain a sample. In fact, the bees were dehydrated and had flown en masse for reason of dire thirst! And, coming from a warm cluster without having to contribute to heat generation, they chilled by the thousands before reaching their goal: water.

Distribution of body weights (empty*) of bees from 'super' and dysenteric colonies.



***After withdrawal of sting apparatus, rectum, bowels and honey stomach.**

Table 3.

	Aver.	Std.Dev.	Aver.	Std.Dev.	Aver.	Std.Dev.
Body, whole	91.3 mg	+ 4.9	143.4	+7.9	145.5	+12.9
Bowel + Hon.stom.	21.9 mg	+3.3	61.4	+ 9.6	60.5	+ 8.6
Body, empty*	65.9	+7.6	75.5	+ 2.8	79.4	+ 3.2
Blood sugar	18.4%	+ 3.8	12.7%	+ 1.9	-----	-----

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