Pollen availability for honeybees in an agricultural landscape and mitigation of pollen scarcity by planting of bee forage

Asger Søgaard Jørgensen, Flemming Vejsnæs and Rolf Theuerkauf
Danish Beekeepers Association
Fulbyvej 15
DK 4180 Sorø
www.biavl.dk
asj@biavl.dk

Abstract
Lack of high quality pollen for honey bees throughout the season is supposed to be an important factor in the major losses of bee colonies seen in many countries. Denmark should with its intensive agricultural landscape be an excellent area to investigate if this is so. Pollen samples of bees has been collected and analysed from several observations bee yards throughout the season.

A total number of 122 plants were represented in the pollen samples, but from all the bee yards only 41 plant species contributed with more than 1% of the single pollen sample. In the individual bee yards the number of important pollen plants were even as low as 12, with only 2 – 3 species represented at any time of the season. Potatoes were shown to be an important pollen provider in some areas with intensive production of potatoes for industry.

Data from 1941 are compared with data from 2011 showing marked decrease in the number of important pollens and even total disappearance of pollen of Corn flower.

Introduction

Colony Losses are considered caused by many single factors as well as combinations of factors. The main factors being:

- Varroamites and insufficient treatments
- Use of pesticides in agriculture as well as for parasite control in the beehive
- Winter-losses due to climate changes
- Combinations of stressors
- And lack of quality bee forage mainly lack of pollen of adequate amount and quality.

Lack of high quality pollens could be a problem in Denmark and the agricultural areas of Denmark could be a proper place to investigate this, as we have experienced fewer losses caused by the other factors. Generally speaking Danish Beekeepers do control their varroa mites efficiently by ecological methods; the use of pesticides in agriculture is limited compared to other countries. We have little long distance migratory beekeeping.
Some winters we experience heavy losses of colonies. But we have seen no increase in these incidences during the years.
Denmark has the world's most intensive agricultural landscape. More than 60 % of Denmark is arable land of which 92% is under crop rotation.
The main crops are Winter Wheat, Maize, Sugar Beets and Potatoes. For the bees we have about 170.000 hectares with Winter Rape Seeds. Some areas with organic grown pastures for organic milk

production and on the Eastern Islands we have 4.000 hectares with production of White Clover seeds.
There are some orchards with fruit production apples, strawberries, raspberries.
Towns, roads etc. are 20%, 12 % forest and the rest is heather, dunes, meadows.
In the agricultural landscape we have abundant nectar and pollen some periods of the season, but other periods the landscape is a desert for honeybees and other beneficial insects.
Observation bee-yards with electronic hive scales and temperature logger have been set up.
From the observation bee-yards we can see that some parts of the season there is an abundant nectar flow, but regularly we find in the agricultural landscape a dearth period during June with lack of flow. The nectar flow stops normally mid-July.
There is a lack of nectar yielding bee forage in parts of the season.

In this project we want to investigate if the same counts for the pollen supply and which plants contribute to the pollen supply in an agricultural landscape. An important part of the project is also to provide information to farmers, hunters, foresters and beekeepers of which plants to use when creating biotopes for wildlife and pollinators.

Material and method

Beekeepers apply pollen traps on one hive in the observation bee yards. In 2011 we collected pollen once a month, but the data showed several gaps so 2012 we collected pollen 1 or 2 days each fortnight during the season. The collected pollen is stored in the freezer until the end of the season.
In 2012 we collected a total of 96 pollen samples.
The samples were analysed to species at the Mellissopalynological laboratory at the Bee Institute in Celle, Germany. 500 pollens are counted and identified in each sample.
From the results we are able to build a calendar of the most important pollen plants in the area.
By means of Google maps, field data and direct surveys the main pollen plants around the bee yards.
In one bee yard we are able to compare the data with similar data from 60 years ago.
An important part of the project is the information and efforts to mitigate the influence of agricultural intensification by establishing biotopes and wildlife refuges in the agricultural landscape.
In cooperation with the Hunters association, the Ornithological Society and the Danish Nature Conservation association we produce information and inputs to politician, administrators, hunters, farmers and beekeepers on how to improve the conditions not only for honeybees but for wildlife, birds and insects in the agricultural landscape.

Results
In 2012 we found pollen from a total of 122 plant species in the agricultural areas of Denmark. Most of these were only represented in the samples with single pollens. 41 species were present with an amount of pollen of more than 1 % of the single sample.

Table 1. The most frequent pollens represented in pollen samples from the agricultural areas of Denmark 2012.

Plant	Plant Species	Found in percentage of samples
Trifolium repens	White Clover	55

Taraxacum officinale	Dandelion	52
Epilobium sp.	Willow herb	38
Graminacea	Grasses	37
Violacea sp.	Viola sp.	35
Pyrus sp.	Pomaceaous fruits	31
Brassica napus	Rapeseed	31

Pollen of grasses was quite common. If you divide grasses in pollen of *Zea maize* and other grasses *Zea maize* was only found in7% of the samples and in all samples with less than 1% of the total amount of the sample.

We have developed a pollen calendar for each of the participating bee yards.
One example is from the bee yard in an intensive agricultural area in the north western part of Denmark. But an area with a number of organic cattle farms in the vicinity as well as some seed production of White clover seeds and Horse radish seed. There are some large fields of potatoes for industrial purposes.

Table 2. Pollen calendar for an agricultural area in North West Denmark. Percent of total pollen load.

Plants/ date		**3.5**	**22.5**	**11.6**	**28.6**	**21.7**	**17.8**	**31.8**
Brassica sp.	Rapeseed/kale	75	31					
Alnus	Alder	10						
Taraxacum officinalis	Dandelion	6				6		
Acer sp.	Maple		35					
Pyrus sp	Stone fruits		15					
Aesculus hippocastanium	Horse chestnut		7					
Sinapis alba	White mustard			68				
Rosa sp.	Roses			12				
Raphanus sp.	Horse radish			6	75			
Tifolium repens	White Clover				8	95	94	62
Symphytum sp.	Comfrey				5			
Solanum tuberosum	Potato							29

In a bee yard in the South Eastern part of Denmark we have been able to compare the pollen data with data collected in 1941. The bee yard is not on the same spot. But both in 1941 and 2011 the bee yards are placed on large estates. In 1941 estates had a large variety of productions. Cattle, seed

production, fruit production. In 2011 the estates in this area of Denmark has mainly concentrated on production of cereals, rapeseed, sugar beet and some production of White clover seed.

Table 3. Pollen of Cornflower and Brassica sp. collected by honeybees in an agricultural area of Denmark in 1941 compared to 2011. Percent of total pollen load.

Plant sp.	April	May	June	Late June	July	Late July	August	Late Aug.	Early September	Late Sept.
Centaurea Cyanus 1941	0	0	0	17	36	59	45	8	0	0
Centaurea Cyanus 2011	0	0	0	0	0	0	0	0	0	0
Brassica sp. 1941	0	2	19	36	19	6	8	0	13	38
Brassica sp. 2011	1	1	51	1	0	1	0	1	0	0
Number of species 1941	4	10	10	7	6	8	5	6	7	5
Number of species 2011	2	4	3	4	3	2	4		3	

Discussion

The collection of pollens from bee yards placed in agricultural areas of Denmark has provided a possibility to establish a pollen calendar for agricultural areas in Denmark.

Although we had 122 plant species represented in the samples only 41 were represented with an amount comprising more the 1 % of the single sample. That means that in the agricultural areas of Denmark 41 plant species provide pollen for our colonies throughout the season.

White clover proves to be the most important forage plant for our bees (Table 1). Pollen from White Clover was found in 55 % of all samples and in 36 % of the samples it provided more than 30 % of the sample.

Looking at the individual bee yards, the number of important plant species is even much lower. (Table 2). Only 12 plant species provided the bees with pollen during the season of 2011. Again White clover was far the most important pollen plant.

Interesting is that we found pollen of Potato in the samples of this bee yard in 1 sample from 31. August it made up 29% of the total pollen sample.

Also at another bee yard we found pollen of Potato late in the season. The explanation could be that the number of pollen plants at the end of August is very limited in Denmark. And in both areas there are quite big fields with potatoes for industrial purposes. We have no previous results showing honey bees collecting pollen from potatoes.

Comparing results of pollen samples from 1941 with data from 2011 in an agricultural area shows some marked differences. Table 3 shows the results of pollen collection in bee yards placed on some big estates in Denmark. They are not the same. But in 1941 and today the productions on

these estates are similar. In 1941 estates of Denmark had production of cereals, sugar beets, herbage seed production, mainly of grasses and White clover and they had cattle's on grassed fields.
Today the main productions on the estates are cereals, Sugar beets and some seed production mainly White clover seeds. The comparisons show some marked differences.
In 1941 the number of plants species providing more than 1% of the single sample were 2 to 4 times higher than in 2011 providing the bees with a divers pollen supply during the whole season.
In table 3 the results for Corn flower (*Centaurea cyanus*) and for Crucifereaus plants (*Brassica sp*.) are highlighted.
In 1941 Corn flower was an important pollen source for a long period of the season. Corn flower was not found in the samples from this Bee yard in 2011.
Brassicas were also important pollen providers throughout the season in 1941. In 2011 Brassicas was almost only found during the flowering of the Rape seed in May.
These results show some of the effects of use of herbicides in modern agriculture. Corn flowers and wild Brassicas have almost disappeared from agricultural areas.
To be fair in 2012 we found a high percentage of Corn flower pollen in samples from one bee yard placed close to a farm where the farmer was turning from use of herbicides to organic production.

Mitigation of pollen scarcity
From the data it has been possible to pinpoint the most important pollen plants for Danish agricultural conditions. Plants that are on natural to the environment, and that are able to grow under the conditions in the agricultural environment.
The most important plants and plant families are:
Willows, Stonefruits, Malus sp, Maples and Rubus sp. These plants are excellent to use in hedgerows and in biotopes for wildlife providing nectar and pollen from spring until late summer.
For sowing the most important plants are White clover, Sweet clover and Red clover. Brassica species and Corn flower should be recommended.

The study will be finalized by the end of 2013. Next step will be to seek funding to continue parts of the pollen collections and have the most important pollens analysed for nutritional value, as literature studies has shown a marked lack of nutritional data for pollen. See Sommerville 2001.

Acknowledgements:
Thanks to the beekeepers who have contributed with collection of pollen during the whole season. Without their efforts this work would not have been possible.
Thanks to "Promilleafgiftfonden for Landbrug" and the Danish Beekeepers Association for financial support.

Literature
Sommerville, DC. 2001. Nutritional Value of Bee Collected Pollens. RIRDC publication No. 01/047. NSW Agriculture.

Stapel, Chr. and Eriksen, KM 1939. Pollenanalytiske undersøgelser over honningbiernes Trækplanter. Tidsskr. F. Planteavl Bd. 44, 129-157

Stapel, Chr. and Eriksen, KM 1942. Pollenanalytiske undersøgelser over honningbiernes Trækplanter III Tidsskr. F. Planteavl Bd. 4, 307-317