MORPH forecast for carrot fly activity in carrots in Denmark

Purpose:

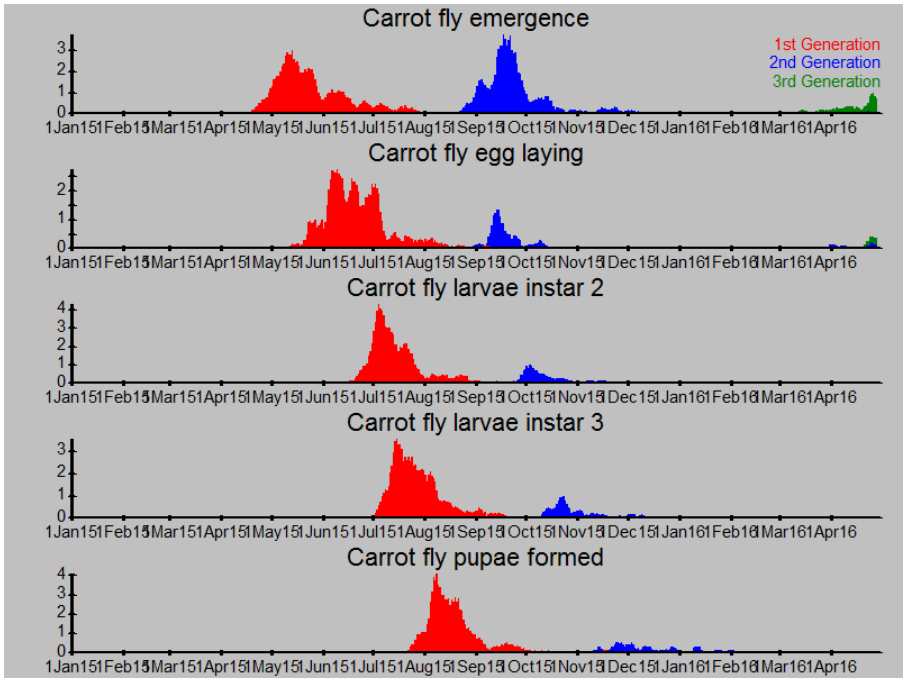
- to measure and collect temperature data for the carrot fly forecast model in MORPH and
- to investigate the possibilities to use MORPH in Denmark to forecast optimal timing of carrot fly control. Control in this context may mean spraying or harvesting before visible attack on roots.

Background:

Carrot flies are perceived as an increasing challenge in carrots in some parts of Denmark. Mainly because the possibilities to control carrot flies with insecticides has been severely limited. There is only one approved insecticide and the application is limited to maximum two seasonal sprays including control of other insects such as cutworms and aphids. The area of organic carrots is increasing and here there is no approved insecticide to control the carrot flies.

Yellow sticky traps are very common in European carrot production to monitor the activity of carrot flies in the carrot fields and used for timing of spraying or in the organic carrot production to identify potential attack and timing of harvest. The use of yellow traps is very sensitive to how they are placed in the field, angulation, wind direction, height and type of fence along the field. But traps do only tell us something about the number of flies caught during the week before, and can't forecast the activity of carrots flies. In some European countries models to forecasting the carrot fly activity have been implemented like in UK with the MORPH carrot fly forecast from University of Warwick. Here they have found that yellow traps as a tool for timing of spraying can be optimized, if they are supported by the MORPH forecasting tool based on the air and soil temperature. The MORPH model for carrot flies uses hourly air temperatures and soil temperatures (6 cm) from 1 February. Based on those data MORPH calculates and predicts when the overwintering carrots files will emerge, lay eggs and develop into larvae for the first and subsequent generations of carrot flies.

Example of output from MORPH model 2015:



Test description:

Four weather stations from Metos and one from Decagon have been set up on 1st of February in carrot fields in different areas in Jutland. In each field and nearby fields, carrot fly activity has been monitored on yellow sticky traps with 5 to 6 traps per field. Spring was very cold in 2015, so carrot fly activity came very late. For this reason the yellow traps were moved to new fields near the weather stations after monitoring the first generation egg-laying.

Temperature data from the weather stations have been collected weekly during the season and transformed through an Excel spreadsheet into a text format that MORPH can read. This is a bit of a challenge because MORPH operates with English dot decimal separation, where Danish computers operate with a comma separation.

The MORPH model from University of Warwick has kindly been made available for testing in Denmark in 2014 and 2015.

In the area around site 5 with the Decagon data logger, another 15 field were monitored for carrot fly activity during parts the season. And near the Metos stations another 3 field were monitored for carrot flies.

Results:

The tables below show predicted dates by which 10% and 50% of flies will emerge/lay eggs at the five locations with weather stations. The days predicted were very stable all spring until middle of May. At that time the temperature dropped below normal (30 years average) and the forecast changed dramatically. The predicted day of emerge did not change but the days for 10% and 50% egg-laying was continuously postponed into June, see table 1, 2 and 3.

The cold weather did also influence the forecast of the second generation. Each week the days for 10% and 50% egg-laying by second generation flies were postponed all the way into end of September, see table 4, 5, 6, 7 and 8.

Table 1. 4th of May MORPH forecast 1st generation carrot fly

Location	Forecast 10% emergence	Forecast 10% egg-laying	Forecast 50% egg-laying
Site 1	24 April	10 May	24 May
Site 2	30 April	11 May	26 May
Site 3	4 Maj	12 May	27 May
Site 4	6 May	14 May	29 May
Site 5	4. maj	12. maj	27. maj

Table 2. 16th of May MORPH forecast 1st generation carrot fly

Location	Forecast 10% emergence	Forecast 10% egg-laying	Forecast 50% egg-laying
Site 1	24 April	22 May	31 May
Site 2	30 April	22 May	31 May
Site 3	4 Maj	25 May	3 June
Site 4	6 May	25 May	3 June

Site 5	4. maj	23. maj	3. juni

Table 3. 2nd of June MORPH forecast 1st generation carrot fly

Location	Forecast 10% emergence	Forecast 10% egg-laying	Forecast 50% egg-laying
Site 1	24 April	26 May	8 June
Site 2	30 April	25 May	8 June
Site 3	4 Maj	1 June	12 June
Site 4	6 May	30 May	11 June
Site 5	4. maj	24. maj	8. juni

Table 4. 4th of May MORPH forecast 2nd generation carrot fly

Location	Forecast 10% emergence	Forecast 10% egg-laying	Forecast 50% egg-laying
Site 1	17 July	25 July	8 Aug
Site 2	19 July	26 July	10 Aug
Site 3	20 July	26 July	11 Aug
Site 4	21 July	28 July	12 Aug
Site 5	20. juli	27. juli	9. aug.

Table 5. 2nd of June MORPH forecast 2nd generation carrot fly

Location	Forecast 10% emergence	Forecast 10% egg-laying	Forecast 50% egg-laying
Site 1	3 Aug	9 Aug	23 Aug
Site 2	3 Aug	9 Aug	23 Aug
Site 3	6 Aug	12 Aug	27 Aug
Site 4	5 Aug	10 Aug	26 Aug
Site 5	1. aug.	9. aug.	23. aug.

Table 6. 5th of July MORPH forecast 2nd generation carrot fly

Location	Forecast 10% emergence	Forecast 10% egg-laying	Forecast 50% egg-laying
Site 1	11 Aug	20 Aug	1 Sep
Site 2	13 Aug	21 Aug	2 Sep
Site 3	21 Aug	27 Aug	9 Sep
Site 4	16 Aug	23 Aug	4 Sep
Site 5	8. aug.	15. aug.	28. aug.

Table 7. 4th of August MORPH forecast 2nd generation carrot fly

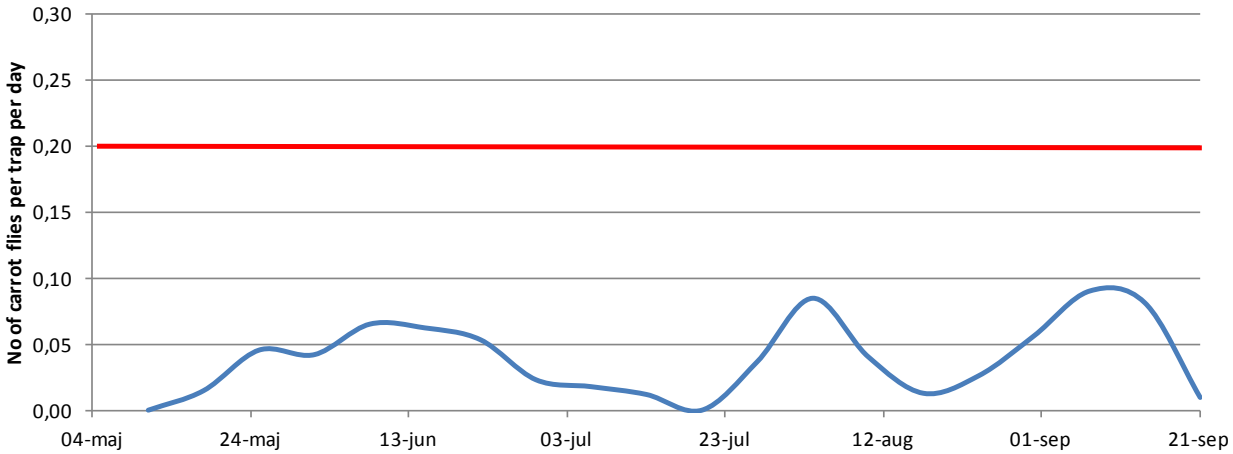
Location	Forecast 10% emergence	Forecast 10% egg-laying	Forecast 50% egg-laying
Site 1	17 Aug	24 Aug	5 Sep
Site 2	23 Aug	28 Aug	9 Sep

Site 3	29 Aug	2 Sep	12 Sep
Site 4	22 Aug	28 Aug	9 Sep
Site 5	11 Aug	20 Aug	1 Sep

Table 8. 7th of September MORPH forecast 2nd generation carrot fly

Location	Forecast 10% emergence	Forecast 10% egg-laying	Forecast 50% egg-laying
Site 1	17 Aug	23 Aug	5 Sep
Site 2	24 Aug	29 Aug	11 Sep
Site 3	2 Sep	8 Sep	15 Sep
Site 4	20 Aug	26 Aug	7 Sep
Site 5	12 Aug	18 Aug	31 Aug

The MORPH forecast for the first generation in 2015 does not differ much between the different sites, but a little bit more than 2014. In 2015 there was one week difference between spray-start of the first field to spray-start in the last field. But still it looks like the forecast for first generation can be used for a larger region then just a local site.
At the time of the second generation carrot fly activity, there is much more differences between the five locations – with nearly 3 weeks between the earliest location and the latest location. So when using the MORPH forecast for the second generation of carrots flies, the soil and air temperature data needs to come from a local weather station.



The carrot fly activity has been monitored on 23 fields in the same areas in Jutland as where the weather stations were placed. Fields at site 1-5 is where the weather stations were located. The figure above shows the average number of flies caught on the yellow traps in all fields. Because the weather most of the summer was cold a rainy, the activity of the carrot flies has been very low all season and without clear peaks. Only on three of the locations the threshold was exceeded one or two weeks. After end of monitoring in this project, the catches peaked in last two week of September on the last few locations of the national monitoring system (not in the figure). It looks like the carrot fly egg-laying activity was spread out over the whole season on a very low level and maybe with a peak too late to be of any importance for the carrot production.

This was more or less also the message from the MORPH-model which did postpone egg-laying activity repeatedly.
Only very few fields were sprayed this season, but spraying might have had an influenced on the number of flies caught on the traps in those fields. On site 5 spraying were scheduled to be done according to MORPH. But spraying was not carried out because of bad weather and low number of flies on the traps.

Last year carrot fly egg-laying activity came very early for both first and second generation. This year the egg-laying activity came very late and was prevented by bad weather conditions for the carrot flies. In both situations it looks like MORPH did predict this on large scale. Based on these tests, it's not possible to determine whether the MORPH results correlated with the egg-laying activity on field level.

Number of carrot flies on yellow traps in carrot fields on 23 location in the same area where MORPH model has been operated in Jutland 2015

	11-maj	18-maj	25-maj	01-jun	08-jun	15-jun	22-jun	29-jun	06-jul	13-jul	20-jul	27-jul	03-aug	10-aug	17-aug	24-aug	31-aug	07-sep	14-sep	21-sep
	number of carrot flies per trap per day																			
Site 1	0	0,06	0,37	0,14	0,26	0,34	0,34	0,09	0,06	0	0	0,14	0,54	0,34	0,06	0	0,17	0,06	-	-
Site 2	-	-	-	-	-	-	-	-	-	-	0	0	0	0,03	0	0,03	0,06	0,11	-	-
Site 3	0	0	0	0	0,06	0,11	0	0,03	0	0,03	0	0,06	0,03	0,06	0,03	0,06	0,03	0,03	-	-
Site 4	-	-	-	-	-	-	-	-	-	-	0	0	0	0,06	0	0,03	0,06	0,09	-	-
Site 5	-	-	-	-	-	-	-	-	-	-	-	-	-	0,03	0,02	0	0,06	0,04	0,14	0
Site 6	0	0	0	0,04	0,07	0,02	0	0,06	-	-	-	-	-	-	-	-	-	-	-	-
Site 7	0	0	0	0,04	0,03	0,05	0,02	0	-	-	-	-	-	-	-	-	-	-	-	-
Site 8	0	0	0	0,03	0,03	0,02	0,04	0	-	-	-	-	-	-	-	-	-	-	-	-
Site 9	0	0	0	0,06	0,03	0	0,02	0,03	-	-	-	-	-	-	-	-	-	-	-	-
Site 10	0	0	0	0,03	0,03	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-
Site 11	-	-	-	-	-	-	-	-	-	-	-	-	-	0,05	0,05	0	0,07	0,24	0,4	0,08
Site 12	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0,02	0	0,24	0	0
Site 13	-	-	-	-	-	-	-	-	-	-	-	-	-	0,05	0,02	0,07	0,02	0,14	0	0
Site 14	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0,02	0	0,14	0,05	0
Site 15	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0,02	0,02	0
Site 16	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0,08	0,04	0,1	0
Site 17	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0,17	0,15	0,05	0
Site 18	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0,02	0,06	0,08	0,13	0	0
Site 19	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0,1	0,12	0
Site 20	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0,07	0,05	0,02	0,02
Site 21	0	0	0,03	0,06	0,06	0,03	0	0	0,03	0	0	0	0	0,03	0,03	0,09	0,09	0,03	-	-
Site 22	0	0,06	0,06	0,03	0,09	0,03	0,03	0	0	0,03	0	0,03	0	0,06	0	0,09	0,03	0,03	-	-
Site 23	0	0,03	0	0	0	0,03	0,09	0,03	0	0	0	0,03	0,03	0,03	0	0	0,03	0	-	-
Ave.	0,00	0,02	0,05	0,04	0,07	0,06	0,05	0,02	0,02	0,01	0,00	0,04	0,09	0,04	0,01	0,03	0,06	0,09	0,08	0,01

Conclusions:

- Converting data from the Metos weather stations into MORPH is a challenge. This needs programming if it's going to run automatically in large scale.

- It looks like MORPH can be used to forecast the first generation of carrot fly activity for a larger region because the differences between locations are small. To forecast the second generation activity the weather data needs to be more local.
- The tests indicate that there might be a correlation between the model forecast, and the actual activity displayed on the yellow traps in the fields.
- When the decision to spray is based only on yellow traps, spraying will often be too late. When fly activity peaks on the yellow traps, most of the eggs will all ready have been laid. The yellow traps are on the other hand a very good complement to the MORPH forecast, verifying the accuracy of the model.
- The MORPH model might predict when the carrot flies are laying eggs but can't predict if the threshold is going to be exceeded. That's where the yellow traps become useful.

Weather station with rain gauge and temperature sensor in air and soil.

Yellow traps for carrot flies 10 meter from fence and 10 meters apart.

Carrot fly attack on root.

LRM, 2015