Scanning & analysing individual bee (*Apis mellifera* L.) behavior using RFID

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Abstract

A complete system to make real-time flight entrance observations possible is described. The system consists of:

a. **RFID reader** covering the flight entrance of a colony in a standard hive (25 cm wide). Each passing tagged bee is detected. ID, day, time is stored in the database and shown via the web-interface.
b. **ApiScan** covering the same entrance width; giving in and out flight-activity on an individual basis.
c. **Camera** allowing a permanent remote observation and registration of behavior at the flight entrance.
d. **Weather station** registering air temperature, air humidity, wind velocity and direction, rain. The equipment and the data storage allows an in-depth analysis of the flight behavior of the worker bees during the measuring period or the lifespan of a worker bee.

Keywords: honeybee, RFID tags, foraging behavior, automatic monitoring

Need for individually marking honey bees

The tunnel and field tests are the higher tier risk assessment to the honeybee colony for plant protection products (PPP's) based on Directive 91/414/EEC criteria. Those tests have to disclose "through an appropriate risk assessment that under field conditions there are no unacceptable effects on honeybee larvae, honeybee behavior, or colony survival and development after use of the plant protection product according to the proposed conditions of use" [1] .

The only natural way for a PPP to contaminate the matrix honeybee-colony is to be carried into the hive by gathering honeybees.

This very first step - flying back from a contaminated source into the hive - has been used to find effects of field relevant sublethal doses of different insecticides for the honeybee: for deltamethrin[2], imidacloprid[3,4,5,6,9], fipronil[5,7,8] and clothianidin[9].

Instead of direct visual observation of individually paint marked bees, Decourtye[8] and Schneider[9] used modern RFID-techniques to register behavior of foragers in their experimental setup. The passive RFID-chips tagged on the thorax of a honeybee weigh 3 mg, adding about 3% to her bodyweight.

The chip-size is comparable to the classical numbered tags used for marking worker and queen honeybees. For this small-size passive chip a distance from the reader of max. 5 mm guarantees a secure identification of the marked honeybee.

Up till now the existing research set-ups with this technique [8,9] use small entrance holes (tunnel diameter <= 7 mm), which restricts the number of bees under observation during each experimental session.

Also the classical automated observation tool on flight entrance activity uses small entrance-holes to allow each bee to individually pass an infrared counter (the BEESCAN BEECOUNTER ®from Lowlands electronics). This equipment is judged as unreliable. At high flight activities the equipment hampers the natural behavior of the colonies under observation and the data body produced is inconsistent.

Alix et al.[10] postulate: "Possible effects on adult survival and foraging behavior and on bee colonies should be checked". This urgently asks for an automated observation of the flight entrance on the basis of individually marked bees. The equipment used should not limit the passing through the flight entrance.

RFID reader and tracking software

Co-author Egbert Touw, as a social responsibility project in the light of the high colony losses in the Netherlands, managed to initiate his employer - Nspyre - to develop a RFID reader design covering the full width of the flight entrance of a standard hive (25 cm). As partner in the cooperation Microsensys GmbH in Erfurt (D) developed a reader using 16 overlapping antenna areas, fit to detect and read-out the passages of their MIC-3 tags .

A number of students of Fontys Hogeschool Eindhoven co-developed the tracking system e.g. the software behind the row of reader antennae. The whole setup integrates the data from a RFID-scanner, a video observation, a weather station, an APISCAN counter. All these data are collected and stored in real time and can be linked to the internet.

Demonstration

At the Floriade Horticultural World Expo in Venlo NL (5th April -7th October 2012) a complete system is active and all these data are shown in real-time together on a web interface (46" monitor) in the Bijenpaviljoen (Fig. 1).

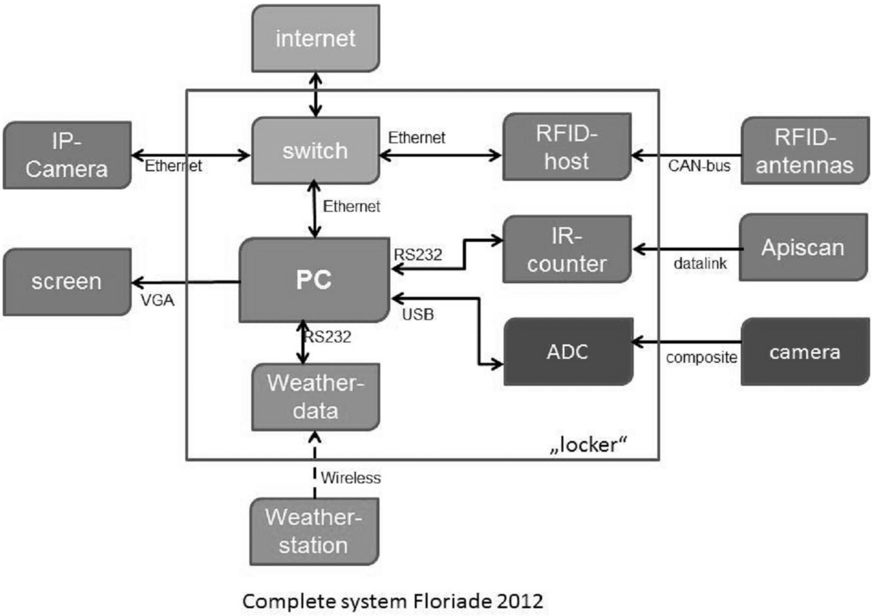

Fig. 1 Dataflow-schedule of the complete system as shown on *Floriade*.

The equipment and the data storage allow an in-depth analysis of the flight behavior of the worker bees during the measuring period or the life span of a worker bee. Changes in behavior eventually due to the use of a PPP can be easily detected and traced thanks to the real-time registration and logging of all the relevant parameters. The system allows the tracing of individual honeybees in there natural environment as part of a whole, normal sized colony (up to 50.000 individuals).

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