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NOTES AND COMMENTS

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An integrated system for field studies on honey bees

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ABSTRACT

Semi-field and field studies on honey bees using colonies are necessary to obtain more biologically relevant data, but are often hampered by logistic constraints. The use of small colonies in miniature hives is regarded as an acceptable approach to such studies, but the equipment designed for commercial and hobby beekeepers may not be appropriate or effective for research purposes. Here, we propose a novel integrated system of research equipment in which each item is designed and built in a coordinated fashion to improve speed, ease, reliability, and accuracy. The system is built around the Study Frame and includes a converter hive, photographic equipment, and combined floor, stand, varroa tray, dead bee trap, and pollen trap, thereby allowing for a wide range of scientific purposes.

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Ecotoxicology studies on honey bees are designed to detect subtle and sublethal impacts of single or multiple plant protection products, possibly in combination with other stressors. Field and semi-field studies on honey bees are for convenience frequently based on the use of hives that are available locally. Such hives and their associated equipment, while suitable for amateur and commercial beekeepers, may not be the best for ecotoxicology studies; the weight, size, difficulty of measurement, and observation plus the strength of populations may affect performance, particularly by researchers who lack experience and confidence.

The authors describe an integrated system of equipment for honey bee studies based on the following principles:

1. Small colonies are easier and quicker to handle, measure, and observe. The system can sustain stable colonies as small as 3000 adults.
2. The creation of small research colonies is done by using Converter Hives to transfer bees and brood from large conventional hives to study hives.
3. The assembly of study colonies is done to a high degree of standardisation in terms of brood quantity, adult bee population, and food stores.
4. The basic units of the system, i.e., hive parts and frames, are available from beekeeping equipment suppliers.
5. The special parts of the system are designed for easy use, and for the delivery of large amounts of verifiable data.

The system is based upon a small German hive widely used for queen rearing, which is sold under the name Mini Plus Beute (MPB). (Holtermann) The hive is made from expanded polystyrene and measures 300 mm × 300 mm in plan view. The insulation is valuable in assisting small populations of bees to maintain stable and long-lived colonies. The frame is 210 mm × 160 mm, providing approximately 1000 cells per side. Other components include a ventilated floor, a clear cover, a feeder, and a roof.

The key component is the Study Frame (Figure 1). This is constructed so that one or both sides can be fitted with a queen excluder cover held in place with clips. It can be used either to cage the queen on the frame, while allowing worker bees to pass freely, or alternatively to prevent the queen from reaching and laying eggs in the frame. Instead of the conventional beeswax foundation, the Study Frame is constructed with moulded black plastic foundation coated with beeswax, which prevents a caged queen from escaping through holes in the wax. The authors have found that queens and worker bees readily accept the plastic foundation even if it is only partially drawn out. Each side of the top bar is laser-engraved with a unique identifier. If the identifier is obscured with wax or propolis, a scrape with a hive tool exposes the recessed burn mark.

The geometry and dimensions ensure that passages for workers are maintained at all times.

The Study Frame is versatile; one example will illustrate the principles of use. A study may require a cohort of 500 individuals to be observed over one

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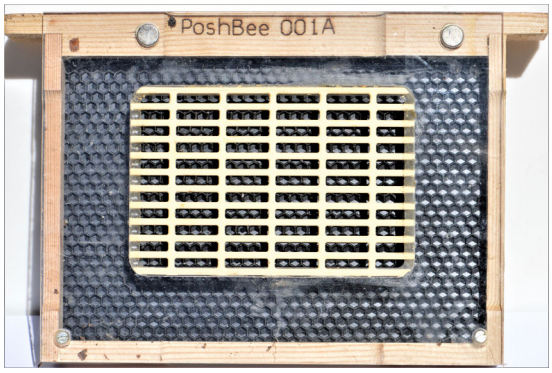

Figure 1. The Study Frame showing the black plastic foundation and the removable queen excluder/acrylic cover.

brood cycle, i.e., egg to adult. A Study Frame with a drawn comb is placed in the donor hive to accustom the bees to it; the queen is placed on the frame and the queen excluder fitted over; the following day the queen is released and the frame returned to the hive with the queen excluder in place to prevent the queen returning and laying eggs at a later date. It is normal for queens in such circumstances to lay many hundred eggs. (Supplemental Figure 1 shows the numbers of eggs laid in each of 33 Study Frames in a recent study to OECD GD75 guidelines.) The date of egg-laying is known so development and impacts can be accurately assessed.

Alternative manipulations allow simultaneous assessments of the impact on eggs and larvae of any selected age, and provision of precisely dated individuals for lab work.

The second special item is the Converter Hive (Figure 2) which utilises the power of a large colony to create a small but stable study colony with a predetermined and consistent number of adults and developing bees. The Converter Hive has a lower brood box that holds conventional frames such as Dadant or Langstroth and an upper box or super that contains the much smaller MPB frames. The queen may be restricted to the bottom box or to the top box by a queen excluder, or she may be free to be in either, depending on management strategy. A typical approach would be to create study colonies seven to ten days before the start of the study by assembling for each colony two frames as full as possible of brood; two frames with comb but no brood; one Study Frame; one frame with the foundation: 300 g of adult bees; the queen; a queen excluder and a super with honey or sugar stores weighing 4 kg.

The third special item is a robust unit (Supplemental Figure 2) which integrates a hive stand, floor, varroa tray, support for scales, dead bee trap, and pollen trap, in order to simplify installation and use and deliver better data. The pollen trap in particular is novel and advantageous for ecotoxicology work, in that the size is appropriate for small colonies and it is easy to use. A small cartridge incorporating a pollen collecting strip and a collecting tray of

Figure 2. The Converter Hive showing conventional large frames and small study frames.

about 15 g capacity simply drops in place across the entrance and is removed a few hours later. The whole cartridge is placed in a sample bag and frozen for later analysis. This enables an accurate and quick assessment of the pollen collection rate, essentially a new and useful endpoint for this kind of work. (Supplemental Figure 3 shows typical amounts of pollen collected in the field.)

The fourth special item is the Photographic Apparatus (Supplemental Figure 4) constructed for taking consistent high definition photographs of brood on MPB Study Frames, primarily for brood studies (Jeker et al., 2011), but also for assessments of colony populations (Hernandez et al., 2020). This comprises an SLR camera with an 85 mm macro lens, an array of floodlights, battery power packs with back-ups, a control panel, remote shutter release, and Study Frame holder, installed in a wheeled housing which is robust and can be manoeuvered easily over rough ground by one technician. Operation is quick and simple, with all equipment pre-set before going to the study location. The small size of the Study Frame enables the Photographic Apparatus itself to be small, at just over a metre long, and light, transportable in a small car. This contrasts with similar apparatus designed to photograph for example Dadant frames which mount on the back of a pick-up truck. Further advantages of the Study Frame are (a) that the black plastic foundation provides excellent contrast when photographing eggs and first instar larvae and (b) photographs of Study Frames are easily handled by image recognition packages (Visionalytics). Supplemental Figures 5–8 illustrate the image quality delivered by the apparatus.

The integrated system of equipment for honey bee studies also includes frame carriers; candy feeders;

winter shelters and a mobile work station for assembly of MPB colonies in the field.

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