

EDIBEE REPORTING EVALUATION 20/DP/8023



Educational platform for Irish beekeepers
(EDIBEE)

Federation of Irish Beekeepers' Associations
(FIBKA) CLG

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1 ACKNOWLEDGMENT

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1.1 INTRODUCTION

The Federation of Irish Beekeepers Associations (FIBKA) competed for the Discover Grant Call for 2021-2022. The project was spread out over a two year period. This made it easier to allow for issues arising from Covid, including the 2-5km lock-down restriction and ban on inter-county travel.

The project aimed to increase/awaken the Science Technology Engineering and Maths (STEM) aspects of beekeeping to both beekeepers and the general public.

1.2 PROJECT OVERVIEW

Two practical hands-on disease workshops were run with 42 main participants in total, who in turn repeated the training process at their local associations. Resources for this training were provided for up to 10 further participants each.

Microscopy workshops to complement the disease workshops were also completed, however, as a result of COVID they could not be run at the same time as the disease workshops as originally planned. Instead, multiple microscopy workshops of a smaller size were completed later in the project, when COVID restrictions allowed.

Microscopes were purchased for the microscopy workshops. Their delivery was delayed due to Covid, but as the workshops were also delayed due to HSE restrictions on indoor gatherings, this did not further affect or delay the project.

In addition to the microscopy workshops on bee diseases, a specialised International Instrumental Insemination (II) of queen honeybees training course was completed. This course was offered to FIBKA members with already a high level of microscopy experience, due to the complex nature of the training. This was followed by further dissemination of this training / experience in Ireland, during a follow-on workshop on Instrumental Insemination (II).

Two STEM Industry workshops were organised:

- Donegal Bees (Glencolumbkille, Donegal) STEM workshop – Donegal bees have a beehive manufacturing facility (wooden hives) and provide the only wax-rendering facility processing beeswax foundation in Ireland.
- Advance Science (Galway) STEM workshop – Advance Science are the producers of 'Hive Alive', a bee feed supplement to support and improve bee health.

Video lectures on beekeeping were created and made publicly available to bring expertise and standardised resources to all areas, including remote regions of the country.

1.3 MAIN PROJECT OUTCOMES

During the practical *train-the-trainer* disease workshops, 500 disease booklets (*Brood Diseases of Honeybees in Ireland*) were distributed. 186 participants returned evaluation forms (37%), showing a respectable return from the activity.

The bee disease *train-the-trainer* workshops demonstrated an achievable, low-cost solution to alleviating a worldwide problem among hobbyist beekeepers: The accurate diagnosis of bee brood diseases.

The booklet "*Brood Diseases of Honeybees in Ireland*" provided a standardised reference method for thorough hive inspections and a clear (text and pictures) explanation of brood diseases.

Microscopy disease workshops with TY students hit the mark from a STEM engagement perspective. It put a practical application to science and incorporated

fun into science. It also engaged a younger audience with bees and bee diseases, who might otherwise not have been exposed to this area.

What we did learn from this cohort was that a focus on direct on-line feedback (e.g. using QR codes) for evaluations is essential.

The training provided (internationally and nationally) on Instrumental Insemination of queen honeybees will ensure that this level of expertise is continued. Continuation of this technique in Ireland is of particular importance to preserve and support the continuation of strong genetic lines of native Irish honeybees (*Apis mellifera mellifera*).

The Donegal Bees (Glencolumbkille, Donegal) STEM workshop provided an opportunity for Irish beekeepers to see the high-tech facilities available in Ireland. It also has the potential to generate income from a valuable hive product (beeswax). Video footage from the day means that some of the material and information shared during the workshop will be available to the wider public (including beekeepers).

The Advance Science (Galway) STEM workshop provided TY students with an overview of career possibilities following STEM education and the variety of opportunities to diversify within the area of STEM (based on personal preference).

It brought bees to a younger audience, who would otherwise not necessarily have been involved with this area. It also highlighted the requirement to engage with them through gamification and in doing this a much higher response rate was achieved.

Video-lectures on beekeeping were created and are publicly available. This provides expertise, information and a standardised resource to all areas, including remote regions of the country for future generations.

The project aim was to engage directly with 120 in year 1 and 1000 in year two. The direct engagement after year 2 has reached 1089 (people who have shown to directly interact with the project). However, additional engagement has been shown e.g. the 'hits' received on one of the video-lectures (just the varroa lecture received 4500+ hits in the first six weeks) and the distribution of the "*An Beachaire*" the Irish Beekeeper magazine with information to another 3500 people.

Although it is difficult to quantify the exact total engagement, it is likely to far exceed the reported 9089 (4500+3500+1089=9089).

1.4 EVALUATORS

- Arjan van Rossum

Arjan van Rossum has a background in biochemistry and molecular biology and is a beekeeper.

- Eleanor Attridge

Eleanor Attridge has a background in Electrical Engineering and is a beekeeper with Senior FIBKA beekeeping exams completed along with CFL & international honey judge exams.

2 BEE DISEASE WORKSHOPS

The *train-the-trainer* bee disease workshops (at the hive) were delayed to July & August 2021. As these were held outdoors, the time delay / impact of Covid was minimal.

There was a benefit to the time delay in the running of the *train-the-trainer* workshops, as it allowed for the creation and development of a brood disease booklet *Brood Diseases of Honey Bees in Ireland* (Appendix 1). The booklet was constructed using Zoom. 13 people (beekeepers) participated in the writing and design of the booklet (60% female). The educational level of the team was at FIBKA Senior Scientific exam level, this allowed for in-depth analysis and concise presentation of the most appropriate practical aspects required in disease recognition.

The booklet provides the first (and currently only) complete and comprehensive guide on brood diseases focusing specifically on the Irish context. It proved highly beneficial at the following *train-the-trainer* workshops (at the hive), as a practical (field-)guide.

2.1 CORK TRAIN-THE-TRAINER DISEASE WORKSHOP

The first *train-the-trainer* bee disease workshop was run in Cork on the 18th July 2021. Two places were made available to each Munster association, however the invitation was extended further across the country when the Munster associations did not all fill their allocation. 21 participants took part in the workshop, covering the

Munster region (18 representatives from all Munster counties), but also two participants from Louth and one from Meath.

While 50% of the places were available for females, the attendance at the Cork workshop from females was (only) 34%. When it was clear that the intended number of places reserved for female participants would not be reached, additional male participants were invited to fill the *train-the-trainer* bee disease workshop. Beekeeping is traditionally a male dominated craft / hobby, with only 29% of all beekeepers being female. The 34% female attendance at the Cork workshop was slightly above the national average.

To be accepted on the *train-the-trainer* bee disease workshops: Participants (beekeepers) ideally should have completed their intermediate beekeeping exams (i.e. have a good understanding of beekeeping, including practical ability). A good understanding of healthy brood and of the lifecycle of the various potential disease agents in the hive is essential to be able to instruct others on diseases. Where those people did not come forward, places on the workshops were filled with less qualified / experienced beekeepers. This allowed more people to take part and learn vital skills, but it also affected the later training sessions, with less experienced beekeepers instructing on material they would not necessarily be (theoretically) familiar with (see Section 2.4, Evaluation).

Seven people were trained up in the first section of this workshop before lunch with time given to identifying issues in the brood nest and Q&A. Lateral flow devices (similar to antigen testing kits for Covid) were available to teach the beekeepers how to identify the notifiable bee brood diseases American Foulbrood (AFB) and European Foulbrood (EFB). The seven participants then demonstrated to two people each at the hive in the afternoon, covering a total of 21 participants. All participants were either directly instructed by (morning session) or instructed with supervision of (afternoon session) the FIBKA Bee Health Officer.

The participants at the *train-the-trainer* bee disease workshops all agreed to repeat the process at their own association apiaries, to re-create the experiential learning in further *train-the-trainer* disease workshop. This provided further dissemination of learning.

The booklet *Brood Diseases of Honeybees in Ireland* was used as a practical guide before and during the *train-the-trainer* disease workshops (Appendix 1)

The booklets were used as instructional material, with a booklet for each participant. Each participant was given a further 10 booklets to use as a tool to disseminate the same material at their own associations on a later date in a similar manner. A total of 250 brood disease books were given out free to various participants directly from the Cork activities. The booklets standardised the training approach taken and allowed for review / revision of material before practical instruction. They have been very positively reviewed by both the trainers and trainees of the various training sessions.

Feedback from the participants on the *Brood Diseases of Honeybees in Ireland* booklet included:

- *"Good images and to the point text"*
- *"I like the durability and ease of use".*
- *"A very useful and professional looking book".*
- *"Finally... a booklet with clear pictures... and good descriptions... thank you!"*



Figure 1: Picture of participants at the Cork train-the-trainer bee disease workshop.

60 on-line evaluation forms were completed from the Cork *train-the-trainer* disease workshop (21 direct participants on the day and another 39 from follow-up training sessions at Beekeepers Associations). The feedback from these sessions was

reviewed and taken into account before the running of the second *train-the-trainer* disease workshop in Co. Louth (Section 2.2).

Follow-on sessions completed after the Cork workshop, where participants repeated the training process at their own associations, highlighted the need for minor changes. The changes made for the subsequent (Louth) workshop were:

- People from the same association should be separated for a better and more meaningful instructional experience – this allows participants to compare experiences afterwards and avoids members ‘taking over’ on the instruction.
- Demonstrate to two only at a time – to allow good visibility of the testing methods and tell-tale signs of disease in the hive. The evaluations highlighted that one participant attempted to complete the disease workshop at the hive with 10 people attending in one session. Feedback showed inadequacies in the delivery and critical feedback on this process.
- While a lot of time was given to looking at *Varroa destructor* infestations and the effects it has on a colony, the words "parasitic mite syndrome" need to be mentioned and linked to the tell-tale signs – this allows people to associate the term with the correct disease pattern. The term was not used at the Cork workshop and a lack of understanding of the term was evident from the evaluation forms.

The team also noted that where possible, evaluations should be completed on the day. This stimulates completion of feedback evaluation forms and increases engagement. It is more difficult (and less successful) to ‘chase’ people for feedback at a later stage.

A paper on the Cork *train-the-trainer* disease workshop was presented at the world beekeeping conference: 47th Apimondia, Istanbul, Turkey in August 2022 and abstract published in the conference proceedings.

Does Experiential Learning at the beehive improve the beekeepers ability to recognise and diagnose diseases through community learning for the hobbyist beekeeper?

Eleanor Attridge MTU, Arjan van Rossum DKIT, Thomas O Mahony MTU

QR code to download the full paper is available in Appendix 2.

2.2 LOUTH TRAIN-THE-TRAINER DISEASE WORKSHOP

The second *train-the-trainer* bee disease workshop was run in Dundalk, Louth on the 22nd August 2021. Two places were made available to the remaining associations nationwide, not previously included in the Cork workshop. 21 participants took part in the workshop, covering the rest of the country (Carlow, Cavan, Clare, Donegal, Dublin, Louth, Mayo, Meath, West-Meath and Wicklow).

While 50% of the places were available for females, the attendance at the Louth workshop from females was 30%. When it was clear that the intended number of places reserved for female participants would not be reached, additional male participants were invited to fill the *train-the-trainer* bee disease workshop.

The same set-up as for the Cork *train-the-trainer* bee disease workshop was used: Seven people were trained up in the first section of this workshop before lunch with time given to identifying issues in the brood nest and Q&A. Lateral flow devices (similar to antigen testing kits for Covid) were available to teach the beekeepers how to identify the notifiable bee brood diseases American Foulbrood (AFB) and European Foulbrood (EFB). The seven participants then demonstrated to two people each at the hive in the afternoon, covering a total of 21 participants. All participants were either directly instructed by (morning session) or instructed with supervision of (afternoon session) the FIBKA Bee Health Officer.

As a result of attending the Cork workshop, one of the participants used the skill-set gained on the day to identify a case of American Foulbrood (AFB) – a notifiable disease. (Notifiable to the *Department of Agriculture Food and the Marine* (DAFM)). This is a very serious disease caused by a spore-forming bacterium (*Paenibacillus larvae*). There is no cure and as the bacterial spores can survive for very long periods (>70 years) in extreme heat / cold, the only method of ‘control’ is to destroy the colony (and all its contents) by burning in order to destroy any bacteria / spores.

The disease was identified a few days before the Louth *train-the-trainer* workshop was due to commence in Louth. The affected stock was left onsite as a teaching tool and used to teach others how to identify AFB and what happens when you get a positive lateral flow (antigen) test.

The stock was destroyed (directly after the workshop), after a sample of contaminated brood was sent to DAFM for confirmation (all according to the regulations).



Figure 2: Picture of participants at the Louth *train-the-trainer* bee disease workshop.

The other notifiable disease in Beekeeping in Ireland is European Foulbrood (EFB). There is a separate lateral flow device (antigen test) for AFB and EFB. The discovery of AFB supported the teaching of using a lateral flow devices and the importance of selecting the correct sample. AFB and EFB affect bee brood of different ages and if the incorrect sample is taken, a negative result can be obtained from an infected colony.

Two other notifiable (DAFM) bee diseases are the Small Hive Beetle (SHB) and the *Tropilaelaps* mite, neither are in Ireland at the time of writing this report.

At the Louth *train-the-trainer* workshop, a further 250 brood disease books were given out free to participants, accounting for a total of 500 booklets between the Cork and Louth *train-the-trainer* workshops.

2.3 ADDITIONAL TRAINING SESSIONS

Further scheduled brood disease *train-the-trainer* workshops were held:

- Cork Beekeepers Association - August 2021 (21 participants) & May 2022 (21 participants).
- Louth Beekeepers Association - Jul 2022 (15 participants)

Additional training sessions were completed by participants from the *train-the-trainer* workshops at their own association apiaries, in their own time.

Participants from all training sessions were given access to the (anonymous) on-line evaluation form and a total of 186 evaluations were completed (out of 500 booklets *Brood Diseases of Honeybees in Ireland* distributed = 37%).

Qualitative feedback was incorporated and feedback analysed (Section 2.4).

2.4 EVALUATION OF THE TRAIN-THE-TRAINER DISEASE WORKSHOPS

The bee disease *train-the-trainer* workshops demonstrated an achievable, low-cost solution to alleviating a worldwide problem among hobbyist beekeepers: The accurate diagnosis of bee brood diseases.

Feedback on the design and the ease of use of the booklet "*Brood Diseases of Honeybees in Ireland*" was very good and the majority felt the photos were a great guide. It also provided a standardised reference method for thorough hive inspections and a clear (text and pictures) explanation of brood diseases.

The hands-on knowledge transfer, through peer learning, proved successful where small groups (2-3) were used, giving the trainee beekeepers more hands-on experience and a chance to ask specific questions.

The majority of beekeepers taking part in any of the training sessions, from experienced to beginners, were not familiar with lateral flow devices and taking samples for AFB or EFB testing. This is a newer skill that needs to be further developed. The onset of Covid and the use of lateral flow devices (antigen tests) in its detection has improved awareness of this type of testing and should help to improve appropriate use of these disease detection kits. The demonstration of lateral flow devices was considered valuable by over 26% of the participants. Following the

disease training, 54% reported they had a much improved awareness of disease recognition.

Feedback from the participants was generally positive, some of the general qualitative feedback included:

- *"I found that seeing the diseases and following a full disease inspection in real life are worth so much more in educational terms than any book or class".*
- *"Well organised! I have to take some expertise home i.e. the use of lateral flow devices. Test kits I normally do not have in my tool box".*

When asked about the documentation received as part of the workshops, the following comments were returned:

- *"The booklet is a very professionally finished pocket guide, it is a very clear and concise guide to the most common bee diseases applicable to Irish beekeepers".*
- *"Book on brood diseases is very well laid out and easy to follow for reference".*

Feedback on the instructors included:

- *"[NAME] was excellent, very thorough, clearly understood and practical. She identified problems and provided solutions and gave of her expertise. Excellent Tutor."*
- *"Very eager for attendees to participate and forthcoming discussion developed fluidly from questions".*

And when asked what they found the most interesting on the day, these were typical examples of the replies:

- *"There were so many snippets of information that [NAME] gave that I didn't know. As beekeepers we don't spend enough time opening hives with other people around and refining or changing the ways we do things"*
- *"It gives me an enhanced level of awareness re- disease when inspecting comb".*

When asked what improvements could be made to the workshop, some of the answers read as follows:

- *"Smaller group to allow everyone to handle frames and see first-hand the various brood diseases".*

From further details in this particular evaluation form, it was clear that the instructor in this case had attempted to repeat the training workshop at their own association with 10 participants at the same time. This was not as intended or recommended and as a result, a reminder message was sent to all contacts reminding them of the importance of repeating this in small numbers (1-3 participants at a time).

- *[it would be beneficial to provide a] "Quiz with photos of various diseases on-line & score to see how competent afterwards"*

This suggestion of an on-line quiz was taken on board. An additional evaluation in the form of an on-line quiz was designed and gave immediate feedback. One of the questions was if the person completing the quiz had previously attended one of the practical bee disease *train-the-trainer* workshops. This allowed us to assess if people who had completed the practical workshop scored better in the quiz, compared to those who had not. The on-line quiz is still open and available to the public (see also Section 3).

Feedback from the first set of evaluation forms was a vital tool to tweak the following workshops.

The original invite looked for people with at least an intermediate scientific qualification to set up the *train-the-trainer* at their own local level. Where those people did not come forward, places on the workshops were filled with less qualified / experienced beekeepers. 38% of those sent as representatives of their associations did not have the required level of background knowledge on the causes, signs and symptoms of bee diseases. Some less experienced beekeepers could not see the correlation between *Varroa destructor* infestation and 'parasitic mite syndrome'. In essence 'parasitic mite syndrome' is the term given to the disease pattern caused by a combination of *Varroa* mites and the viruses transmitted by this parasite. When the beekeeper fails to act in time to keep *Varroa* infestation under acceptable limits, a more serious disease pattern follows. This reflects both the impact of mites and viruses and can lead to rapid decline and ultimate death of a colony.

Less experienced or knowledgeable beekeepers also tended to get side-tracked more into (non-disease related) activities, distracting them from the task at hand. They were also more likely to focus on different types of beekeeping equipment being used in a large apiary, compared to the type they had in their own apiaries. Overall, 50% of participants said dealing with different equipment, taking in new information or their eyesight caused them trouble, causing them to be somewhat side-tracked from the job at hand.

The advantage of practical workshops is that people of various levels can be trained. It should, however, be noted that practical *train-the-trainer* disease workshops (with follow-on training sessions led by participants) work best if participants have a solid theoretical knowledge base. There was significant variation in both theoretical

knowledge and practical experience within beekeepers associations across the country. This project aimed to 'level the playing field' with regard to bee disease diagnosis. Substantial progress has been made, but further improvements and standardisations are required to improve this further. The emphasis for the *train-the-trainer* workshops was on diseases and more fundamental knowledge on diseases is required by the majority of beekeepers at a national level.

Another potential area for improvement is the 'beekeepers beginners courses': Currently each beekeepers association has their own version and format of this training. A standardised approach of both the theoretical content and practical instruction provided for beginners would improve the beekeeping experience for new beekeepers in Ireland. The importance of standardisation was clearly shown in this *train-the-trainer* bee disease component of the SFI project and the booklet *Brood Diseases of Honeybees in Ireland*, was a major element of the standardised approach. Although not included in the original proposal, this booklet has shown to be a game changer in the standardisation of bee disease diagnostics in Ireland.

For many hobbyist beekeepers, the romantic dream is to have a few hives at the bottom of the garden, but if not suitably managed, livestock can lead to dead stock and there is a social responsibility to keep the bees alive and healthy.

The project aim was to engage with 1000 in year two. Evaluations revealed the varroa lecture received 4500+ hits in the first six weeks. "*An Beachaire*" was distributed to 3500. The direct engagement was broken down as 1089 totalling 9089.

3 ON-LINE BEE DISEASE QUIZ

An on-line disease recognition quiz was made available to both the beekeepers who took part in the project and the general public (incl. beekeepers). The quiz was designed in response to feedback from the *train-the-trainer* bee disease workshops.

The quiz was recommended as a refresher for those who took part in the *train-the-trainer* bee disease workshops, but it is publicly available and anybody can access and attempt the quiz. Access to the quiz was shared through social media and to the beekeepers who took part in the initial workshops (in conjunction with the evaluation forms).

Beekeepers from around the world have taken the disease recognition quiz, including from Ireland, England, Scotland, Wales, Canada, USA and Kenya. In total, 390 people engaged with the quiz to test their knowledge / skill set (between 30th August 2021 - 31st December 2022).

One of the questions included asked if the person completing the quiz had previously attended one of the practical bee disease *train-the-trainer* workshops. This allowed us to assess if people who had completed the practical workshop scored better in the quiz, compared to those who had not. On average, participants from the disease workshops performed better (18% overall) than those who did not attend.

The quiz remains live and publicly available at:

<https://docs.google.com/forms/d/e/1FAIpQLSfVlbHazUgKXBekEilmNdbuG6XLnC3ol04rPvjATw9fsbOXxg/viewform>

4 MICROSCOPY WORKSHOPS

As a result of Covid-19, microscopy workshops, due to run in conjunction with the bee brood disease *train-the-trainer* workshops did not proceed at the planned dates. The original plan had been to accommodate the same learners for the practical *train-the-trainer* workshops (morning session) and microscopy bee disease workshops (afternoon session).

The microscopy workshops could not be run at the time of the (outdoor) *train-the-trainer* workshops, due to social distancing requirements in place at the time of the re-scheduled *train-the-trainer* workshops. Once HSE guidelines permitted, the (indoor) microscopy workshops were scheduled (April 2022).

Instead of the two planned disease microscopy workshop sessions, a total of five microscopy workshops were held:

- 1) Three microscopy disease workshops – these were organised with TY students to engage a younger audience in bees / bee health (Section 4.1).
- 2) International bee workshop on using microscopy for Instrumental Insemination (II) – Insemination of queen honeybees in a way that provides control over the genetic progeny (Section 4.2).
- 3) Follow-up Instrumental Insemination (II) workshop in Ireland (Section 4.3).

microscopy bee disease workshops with TY students.

A recurrent response in feedback received can be reflected by this statement: "*Crushing bees and looking at them under a microscope was fun*". This was the general opinion of most taking part.

While making up the nosema samples for microscopic analysis, the participants also got to see the amounts and different types of (undigested) pollen in the honeybees gut. Feedback showed that almost all were able to identify at least 2 types of pollen (98%) and most identified 5 or more types (55.6% - Fig. 4).

how many different pollen grains were in the sample you made up today
45 responses

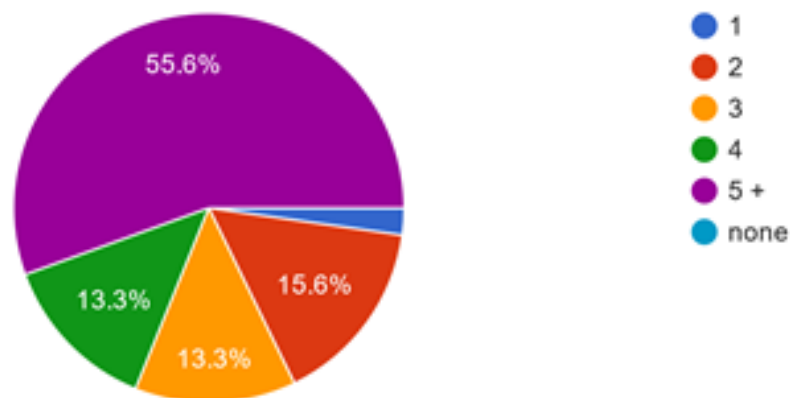


Figure 4: Types of pollen identified in the bee gut at the microscopy bee disease workshops with TY students.

When asked how they would describe the activities to their peers, the following typical responses were returned:

- "*We learnt about a disease of the gut in bees and found out how to identify it under a microscope*"
- "*It's fun and you learn about bees, and have good craic*"
- "*Interesting and a bit disgusting because of the smell of the bees*"

When asked what they disliked about the workshop many of the females (55%) disliked either mashing the bees or the smell they gave off during the process.

From a STEM engagement perspective this workshop hit the mark. It put a practical application to science and incorporated fun into science. It also engaged a younger audience with bees and bee diseases, who might otherwise not have been exposed to this area.

67% of the 86 participants were female (data gathered during the workshops). After the workshops, 66 paper feedback forms were collected, there were some blank feedback forms (21 forms), leaving 45 completed forms (52% response rate).

12% of participants described themselves as being from an ethnic minority.

What we did learn from this cohort was that going forward, a focus on direct on-line feedback (e.g. using QR codes) for evaluations would be beneficial. Similar information was obtained from SFI (the suggestion of using gamification for feedback was presented in an SFI session). This was introduced at a later stage for the STEM Industry workshop with Advance Science, which also included a younger cohort of participants (Section 6).

4.2 INTERNATIONAL MICROSCOPY WORKSHOP ON INSTRUMENTAL INSEMINATION (II)

A facility for training was made available to two participants to attend a specialised Instrumental Insemination (II) of queen honeybees training event in Istanbul in August 2022.

Instrumental Insemination of queen honeybees provides control over the genetic progeny. Due to the complex nature of this procedure, this training was provided to beekeepers with already a good standard of the more common microscopy skills.

The training will ensure that this level of expertise is continued: At the start of the project, there were only 2 people actively implementing II of honeybees in Ireland (both 65+ years of age).

Continuation of this technique in Ireland is of particular importance: II is common practice for honeybee breeding in other countries. Ireland is the last (large)

stronghold of Native Irish Honeybees (*Apis mellifera mellifera*, also called the Black Bee or the Dark European Honeybee) in Europe.

Training on this highly specialist equipment and knowledge transfer to a new generation of beekeepers will support the continuation of strong genetic lines of native Irish honeybees (*Apis mellifera mellifera* - *Amm*). This subspecies was originally widespread throughout the whole of northern Europe, but hybridisation with other sub-species means it is no longer prevalent there.

Native Irish Honeybees are still the most widely found bee in Ireland and are kept by most beekeepers. This subspecies is, however, threatened by hybridisation with imported non-native bees, as well as the effects of diseases that may be imported with non-native bees.

Instrumental Insemination of queen honeybees, will allow continuation of this threatened subspecies of honeybee in Ireland. It will support beekeepers diversify their group *Amm* bee breeding programmes. The current lack of availability of high quality pure-bred *Amm* queens available to beekeepers in Ireland, has led to other honeybee subspecies still being imported from Europe, despite campaigns to stop the importation of (queen) bees. The '*Protection of the Native Irish Honeybee Bill*' has now reached the second stage.

A full report from one of the participants at the Instrumental Insemination workshop may be found in Appendix 3.

4.3 INSTRUMENTAL INSEMINATION WORKSHOP IRELAND

An advanced II workshop was run for a small cohort who were willing to run further workshops themselves regionally at a later stage..

Covid delayed the arrival of the specialised equipment in Ireland but a successful hands on training session in instrumental insemination was completed (August 2022). To select suitable candidates for this workshop, each applicant was asked to submit a short video on a microscopy topic, selected by the evaluation team. Existing knowledge of general microscopy was a pre-requisite for II training, as II includes a very specific additional set-up and careful handling of live bees (both queens and drones). This narrowed the window down to six suitable candidates.

The workshop concentrated on the use of and familiarisation with the equipment for instrumental insemination of honey bee queens. This included sterilising the equipment, particularly those items used for the gathering of drone semen and injection of semen into queen bees.

A session on separating and identifying pollen out of honey using a centrifuge and microscope was also included.

Both of these more advanced skill sets can be taught and used at a local level, by training more specialists in beekeepers associations going forward.

5 DONEGAL BEES (GLENCOLUMBKILLE) STEM WORKSHOP

In the original project application, the proposal was to facilitate 20 people at this STEM workshop, to see their hive manufacturing and wax rendering facilities. Covid delayed the delivery of the workshop (initially through the inter-county travel ban and a second time due to an outbreak of Covid-19 in Donegal Bees). With the delay: The set-up of the STEM workshop was changed to accommodate 40 participants in total (two groups of 20, one in the morning and another in the afternoon). Donegal Bees are located in Glencolumbkille, Donegal (a remote location in the West of Ireland).

They provided two different workshops in two different facilities:

- 1) **Engineering Workshop:** The science and technology behind the manufacture of timber hives, the selection of the timber, the engineering behind the use of the machines and the logistical operation of the plant were introduced and reviewed with all participants on the day.
The importance of taking bee-space into account in the hive manufacturing process was both shown and discussed: Any spaces bigger than a bee-width (6-9mm) will be filled with comb, any smaller spaces will be propolised.
- 2) **Wax workshop:** On the rendering, cleaning and preparation of wax, before using this in the manufacture of wax foundation for brood frames and super frames, including the wiring of wax frames. Donegal Bees have a state of the art facility for this process, the only one of its kind in Ireland. While most of the wax is imported from Spain, there is emphasis put on Irish beekeepers trading in their Irish wax for new wax foundation. Proper rendering / sterilisation of wax is of utmost importance to eliminate any residual pathogens that affect honeybees, that would otherwise be (re-)introduced to (Irish) colonies.



Figure 5: Wax processing facility to turn rendered / sterilised wax into foundation wax for brood and super frames (Donegal Bees, Glencolumbkille).

Both facilities create employment in a remote location in the West of Ireland. This is a developing business and those attending will have taken home ideas to their own beekeeping associations on how they could co-operatively trade-in their rendered wax generating a monetary value for the product.

A report from one of the participants was sent to *An Beachaire* (the Irish Beekeeper) Magazine to circulate to beekeepers (Appendix 4).

Video footage from the day will be available on the EDIBEE YouTube page, after editing has been completed. This means that some of the material and information shared during the workshop will be available to the wider public (including beekeepers).

Feedback forms were distributed (on-line, via e-mail and with QR codes) to all participants of the Donegal Bees STEM workshop. Out of the 40 participants, 20 completed feedback forms were received (50%). This lower than expected level of return may be indicative of the older age group generally associated with beekeeping and their interaction with on-line systems. 50% of the feedback forms were from 50-60 year old beekeepers (Fig 6).

Which age bracket do you fall into
20 responses

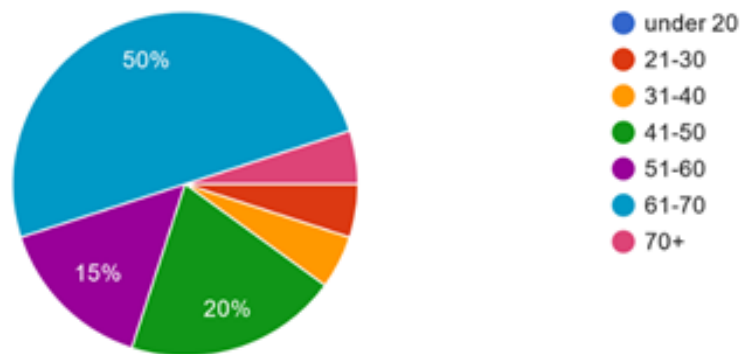


Figure 6: Age of participants at the Donegal Bees STEM workshop.

The participants came from across the country (Armagh, Carlow, Cavan, Clare, Down, Dublin, Galway, Louth, Limerick, Meath and Wexford) and 30% of the participants were female (assessed during the workshop). 50% of the places were available for females, but when it became clear that the intended number of places reserved for female participants would not be reached, additional male participants were invited to attend. Beekeeping is traditionally a male dominated craft / hobby, with only 29% of all beekeepers being female. The 30% female attendance at the Donegal Bees STEM workshop was reflective of the national average. Of the 20 feedback forms received, 40% were submitted by female participants, indicating a slightly higher likelihood for females to provide feedback, compared to males.

Are you?
20 responses

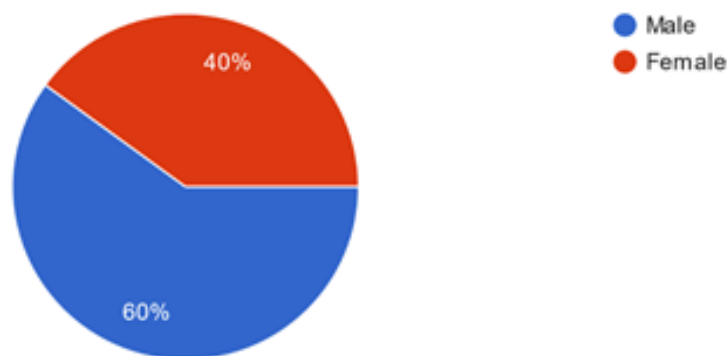


Figure 7: Gender of participants at the Donegal Bees STEM workshop.

- *“This should/could have been a video distributed to all the associations, nothing today warranted a 6 hour round drive with the price of diesel. Very eco unfriendly!! Lunch was lovely!”*

This was the only negative feedback on the workshop, the travel distance required to attend. Donegal Bees (Glencolumbkille) has the only wax producing facility in Ireland and the organising team felt the attendance would provide a more detailed and in-depth understanding of the processes involved.

When asked if they got any ideas from the workshop to take back to others in their associations, the following was received:

- *“Not sure if it would be economically viable but, it would be great to develop a way of centrally collecting all the wax collected by members of your Association for instance, in whatever form, to process, as a service to members, for a fee, and then to develop many different ways of using it in a variety of commercial pursuits. I personally would love to have somewhere I could just bring my wax waste to rather than individually processing it down at home”.*

If implemented this could generate an additional source of income for some beekeepers and/or their associations. This suggestions was shared with all participants and associations, as it provides a practical and easily attainable goal of re-using even smaller amounts of wax, a valuable hive product.

If this workshop was to be run again, we would suggest a candle making demonstration to showcase the potential of added value for rendered wax.

6 ADVANCE SCIENCE (GALWAY) STEM WORKSHOP

The originally proposed Advance Science workshop was supposed to run in the Galway ‘Hive Alive’ office, with a small cohort to demonstrate STEM to school-going people. ‘Hive Alive’ is a bee supplement to help improve general bee health. Covid, a lack of space for social distancing and outsourcing of products on-site within the company prevented this approach. Instead, an overview of science career pathways and STEM within the Advance Science company were brought to TY students in school.

Two employees of Advance Science gave presentations on their science careers: How they started, why they chose Science as a career and how they ended up working in Advance Science.

- 1) One did physics and worked for 10 years with underwater robots, spending a lot of this working time travelling the world. He then went on to develop 'Hive Alive' - a seaweed based food supplement for bees. Advance Science now supply beekeepers with 'Hive Alive' in 45 countries.
- 2) The other did a degree in pharmacology and went on to do a Masters. She demonstrated how your career plans change as you go through life. Work contacts brought her to 'Hive Alive' and awoke an interest in nutrition for bees. She gave an overview of the science behind and importance of bee nutrition.

TY students were eager to hear about different options and pathways that a college degree in science can provide. The variety of opportunities and potential travel you could do after having gained a STEM qualification created a real 'buzz'.

There were 83 participants at the Advance Science STEM workshop. Feedback was received through on-line forms (QR code). In addition, Kahoot! (a game based learning platform) was used to engage the participants with the workshop activities. We had 59 responses from participants (through QR code feedback forms = 71%), but more engaged with the Kahoot! portal (76 participants = 91.5%). There was good gender balance with 47% male and 53% female participation.

8% described themselves as non-Irish, of European decent. 10% had honeybees or a beekeeper at home, which is high considering the national average (± 4500 beekeepers in Ireland, out of a population of 5 million = $\pm 0.1\%$).

The first presentation on the exploration of underwater worlds of different oceans, provided feedback comments such as:

- *"It was cool you could see a lot of stuff that wouldn't be found on the surface"*
- *"I feel it was educational showing us what the deep sea looks like and showing us the build-up of sulphur and how ecosystems thrive off of the bacteria from under the water"*
- *"I feel it has given me a better insight than if someone was explaining to me because I'm a visual learner and that's how I best learn"*
- *"Learn about nature and marine engineering"*

7 VIDEO-LECTURES

As part of this project, a series of video-lectures has been created and published online. The lectures are published on a YouTube Channel:

https://www.youtube.com/channel/UC0cm6h73iojwX_09VEi-O1g

The workshops (disease workshops, industry workshops) were used to obtain footage for use in the video lectures. In addition, separate follow-up sessions were held, to obtain specific footage to highlight important aspects for the videos.

The series of video lectures has been very successful. So far, a number of beekeeping associations have asked for permission to re-broadcast them on their associations' websites, both in Ireland and in the UK. For example, Dunblane & Stirling Beekeepers Association (DSBA) in Scotland has a link to the videos at:

<https://dunblanebeekeepers.com/free-educational-videos-from-edibee/?fbclid=IwAR2srsFZFRkHkR1aZhvaH4PTAX7k5mCjqK-mGGF6jWqlkoWePN5dCRQadsQ>

In addition to the milestones of creating the main video lectures, additional (shorter) videos are being put together to help beekeepers on particular subjects. The video footage for these has been obtained during the apiary disease workshop filming sessions around the country. This will provide further video resources for beekeepers in Ireland and abroad.

Appendix 6 shows a screen shot of the analytics of the EDIBEE YouTube page from January 2023.

7.1 VIDEO-LECTURE ON SWARMING

Video is complete and launched on the YouTube channel at the following link:

https://www.youtube.com/watch?v=uWzzLd_AuAc

Hits to date: 951

Some of the feedback from public viewing:

- *"Thanks for explaining it so clearly"*
- *"Very informative thank you for explaining so thoroughly"*
- *"The shared knowledge is very much appreciated and helped me through my first year as a beekeeper."*
- *"Excellent video"*

A number of shorter video excerpts associated with this video are also on YouTube, including how to make an artificial swarm and how to clip and mark the queen to prevent swarming.

7.2 VIDEO-LECTURE ON VARROA DESTRUCTOR

Video is complete and launched on the YouTube channel at the following link:

<https://www.youtube.com/watch?v=oUoRf0aEgU0>

Hits to date: In the first 30 days this video had 3000 hits and 35 likes. It was promoted through Facebook beekeeping sites and engaging with the public. Currently at 5800 hits.

Some of the feedback from public viewing:

- *"keep up the good work"*
- *"Just found your site. Top job"*

A number of shorter videos were also generated demonstrating:

- The use of Apiguard and how to apply it
- The use of Apibioxal and how to apply it
- The use of Apivar and how to apply it

This video lecture is by far the most shared and watched with feedback coming from places as far away as Australia, where they are only now encountering *Varroa destructor* as an invasive species.

7.3 VIDEO-LECTURE ON IDENTIFYING ISSUES DURING INSPECTIONS

Video is being edited and but not yet launched on the YouTube channel.

Foulbroods have to be dealt with swiftly and this makes the capturing of quality video footage complicated. However, the opportunity presented itself to obtain video footage and we gathered enough footage to put a small video together as a disease identification resource.

7.4 VIDEO-LECTURE ON BEEKEEPING EQUIPMENT

Video is complete and launched on the YouTube channel at the following link:

<https://www.youtube.com/watch?v=aUfDdVUxV5Q&t=117s>

Hits to date: 285

Some of the feedback from public viewing:

- *"Well done. I found this video interesting from start to finish"*

7.5 VIDEO-LECTURE ON THE LIFECYCLE OF THE HONEYBEE

Video is complete and launched on the YouTube channel at the following link:

<https://youtu.be/2VQBclhpTiw>

Hits to date: 491

Some of the feedback from public viewing:

- *"Excellent video... thanks"*

A video on the science and maths on the lifecycle of the three castes of honeybees found in the colony, (Queen, Worker and Drone) and their lifecycles, functions within the hive and lifespans. The relevance of bee mathematics for the beekeeper is introduced in the life cycle, to give a better understanding for honeybee management, moving hives and a better understanding of why and when to check a new queen to see if she has mated successfully and the effect on the colony if she fails to mate.

7.6 VIDEO-LECTURE ON THE EVOLUTION OF THE HONEYBEE

Video is complete and launched on the YouTube channel at the following link:

<https://youtu.be/1jU6U69Pi-k>

Hits to date: 267 view

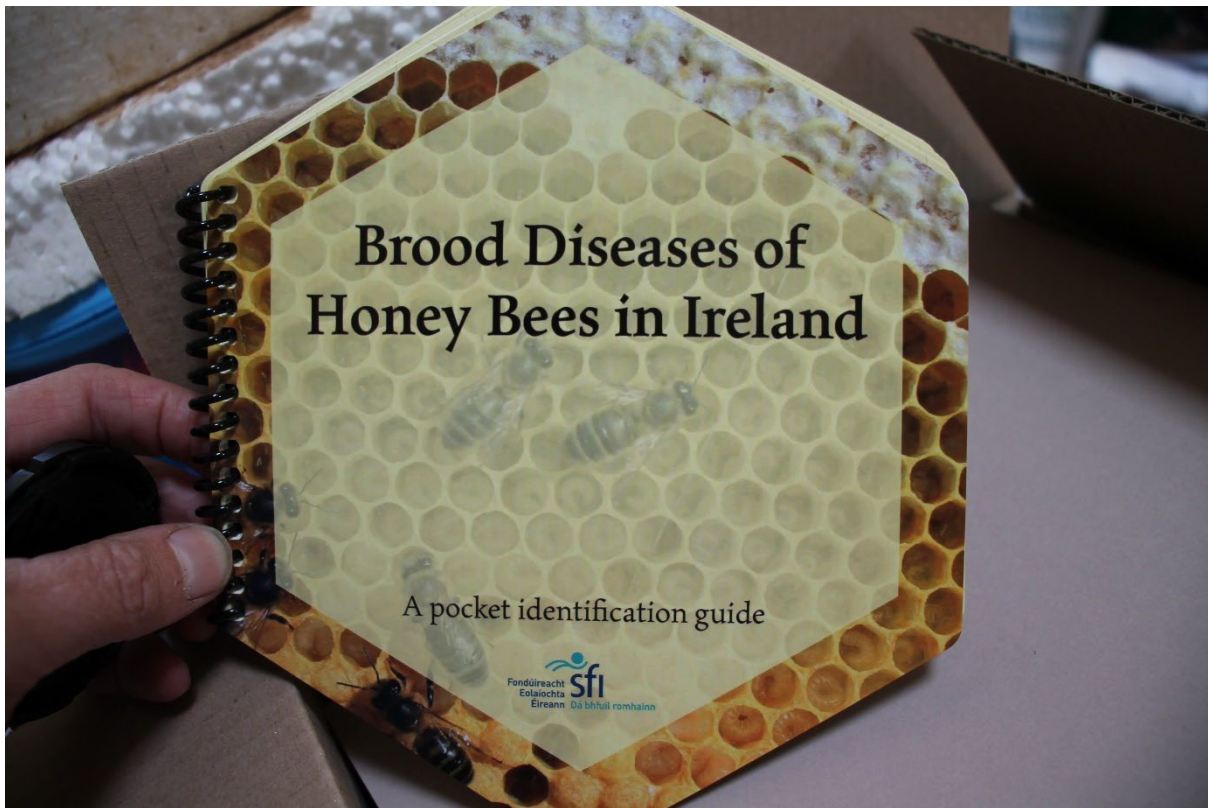
Some of the feedback from public viewing:

- No comments to date

8 APPENDICES

8.1 APPENDIX 1 – BOOKLET ‘*BROOD DISEASES OF HONEY BEES IN IRELAND*’

Booklet – ‘*Brood Diseases of Honey Bees in Ireland*’



8.2 APPENDIX 2 – QR CODE FOR APIMONDIA PAPER

QR code for scientific paper presented at the world beekeeping conference: 47th Apimondia, Istanbul, Turkey in August 2022 and abstract published in the conference proceedings.



Does Experiential Learning at the beehive improve the beekeeper’s ability to recognise and diagnose disease through community learning for the hobbyist beekeeper?

Eleanor Attridge MTU, Arjan van Rossum DKIT, Thomas O Mahony MTU.

8.3 APPENDIX 3 – REPORT ON INSTRUMENTAL INSEMINATION WORKSHOP

Report on International Instrumental Insemination (II) microscopy training workshop.

Instrumental insemination of honey bees

A. Introduction

This document describes in three parts A) an introduction on instrumental insemination of honey bees, B) my experience with the evaluation of the maturation of drones in the 2022 bee season and C) my first experience with instrumental insemination of honey bees at Apimondia 2022, which took place in Istanbul. It concludes in sections D with lessons learned

What is instrumental insemination?

Instrumental insemination is a method of controlled mating of the honey bee queen with use of specialised instruments thereby transferring sperm from one or more matured drones into a virgin queen.

1. The use of instrumental insemination

Instrumental insemination of honey bees can be used for various reasons, amongst them:

- To keep pure breeding lines (male and female) of know genetic material e.g. *Apis mellifera mellifera*;
- To cross-breed between known subspecies or if genetic data are available between different breeding lines within one subspecies (bee strains) ;
- To facilitate research e.g., to identify which bee diseases are transmittable via sperm; and
- Efficient way of insemination, not weather depending.

2. Apparatus

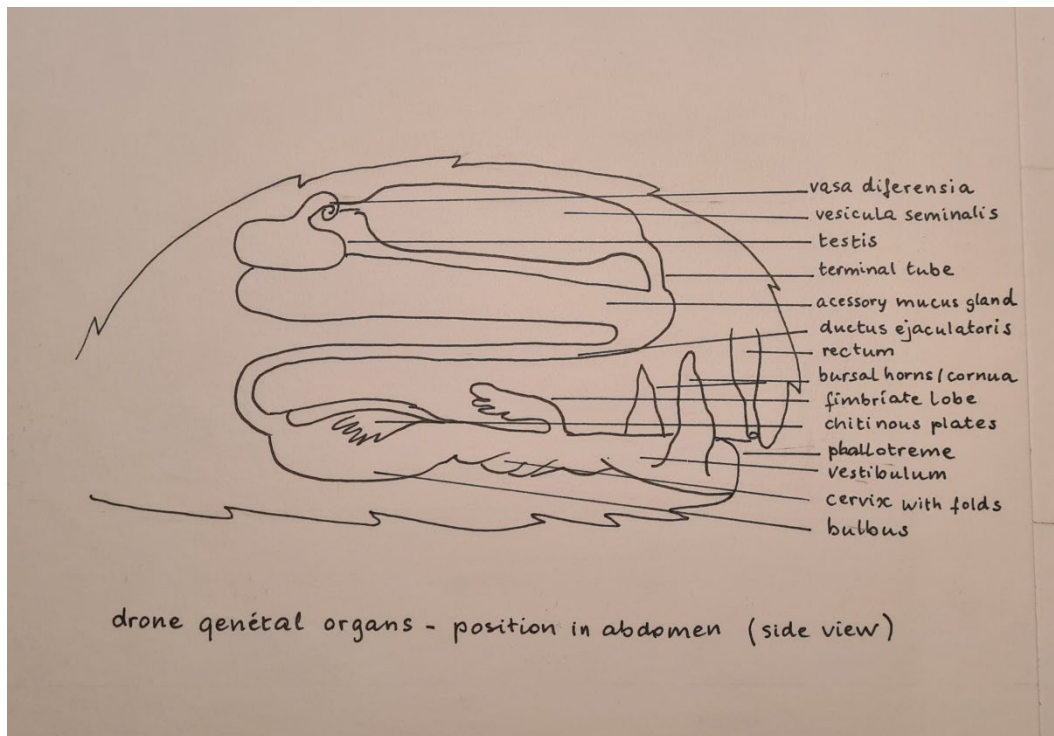
Various models are available for instrumental insemination. All models are based on the following principle:

- A robust stand for micro manipulation;
- Dissection microscope (X10; X40);

- Queen-holder (various measures, depending on the bee species or bee strain) with attachment of two hooks to open the sting chamber. The shape of the hook on the sting side of the chamber is critical;
- Good lighting;
- CO₂ source plus dispenser;
- Glass micro syringe with plunger operated by a very fine screw thread which is the heart of the apparatus. The syringe measurement is critical – not more than 0.3 mm diameter with inner diameter over 0.15 mm;
- Long fine glass capillary tubes for storage of sperm; and
- Additional equipment such as a scale with accuracy of measurement to 0.001 gram; a pH meter; analytical products; recipients, pipets; and a fridge for storage.

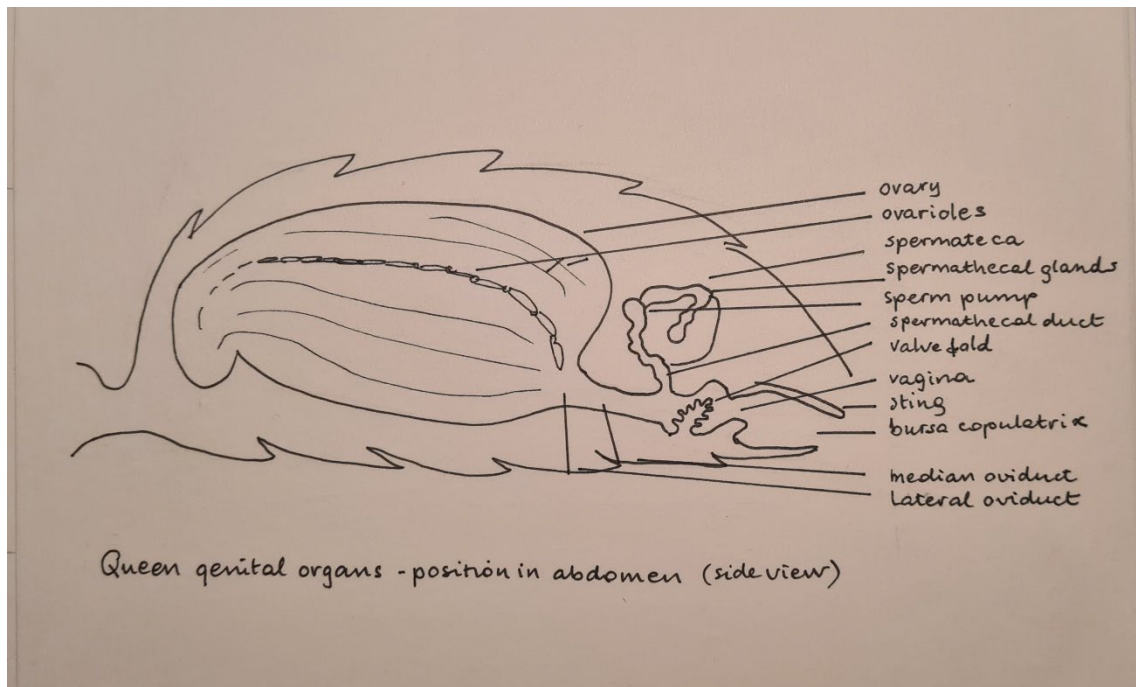
3. Use of drones for instrumental insemination

- The selection of a drone breeder colony is based on previous season's records, which brings it in principle back to the queen performance. The desired traits should be defined. The following traits are indicative: *Apis mellifera mellifera* (or other subspecies or bee strain), fecundity, docility, low swarming tendency, high honey yield, disease resistance, brood pattern, etc.
- To avoid inbreeding, ensure that drones are from another line.
- Insert six to seven weeks prior to insemination drone comb into the drone breeding colony. The drones need 12 -14 days to mature once they emerge on day 24, which corresponds with 38 days after egg laying. If drones are too old, the sperm quality may decrease.
- Mark drones based on age.
- Drones which are 16 – 28 days old are the best to use.



4. Use of queens for instrumental insemination

- The selection of a queen breeder colony is based on previous season's records. The desired traits should be defined. The following traits are indicative: *Apis mellifera mellifera* (or other subspecies or bee strain), fecundity, docility, low swarming tendency, high honey yield, disease resistance, brood pattern, etc.
- Use a suitable queen rearing method to raise queen cells.
- Transfer the queen cell at day 14-15 into a prepared *apidea*® with queen excluder closed at the entrance. A queen needs to mature after emergence for five to six days and is then ready to mate for a next 20 days.
- Queens which are 6 – 8 days old are the best to use.



5. Instrumental insemination method - in three steps

5.1. Stimulation oviposition of the virgin queen

- On day 6 - 8 after emerging, cage the virgin queen;
- Gently threat the queen with a CO₂ flow for about 5 minutes. This flow will stimulate the oviposition.
- Return the virgin queen into the *apidea*®.

5.2. Collection sperm from drones

- Collect sperm from about eight to ten mature drones, which are about 16 days old.
- Have the drones ready and keep them warm.
- Evert the endophallus manually in two steps: a) partially eversion and b) total eversion

a) Partially eversion

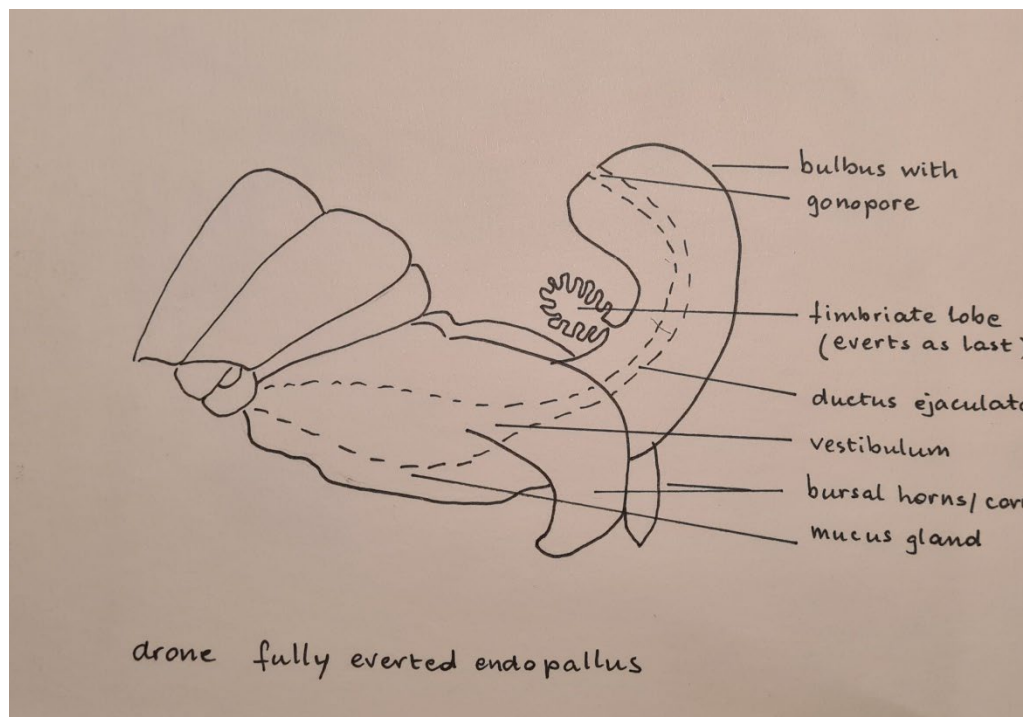
Roll the drone thorax between two fingers; the abdomen contracts and the endophallus partially evert.

If the cornua are not yellow range, the drone is immature and the sperm cannot be used.

b) Total eversion

For a total eversion, press the base of the abdomen. Start dorsal near the thorax and put slowly pressure from the anterior to the posterior side. Pressure is building up in the drone's haemolymph and air sacs and consequently the endopallus flips up, exposing semen. The exposed semen is creamy, marbled with an underlying bed of mucus which is white.

- Collect the semen with the syringe, avoiding the mucus.
- Collect a drop of saline solution to make contact with the semen, avoiding excess. For the next drone, expel a drop of semen.
- Each drone produces about 1 μl (microliter) of sperm. The required dose is 8 – 10 μl .
- Repeat the collection of sperm with other drones till this amount is collected.



5.3. Insemination of virgin queens

- Take the virgin queen out of the *apidea*® and place her in the queen manipulator.
- Provide some CO₂ flow and gently move her backward with a maximum three, but preferable one segment exposed.
- Separate the abdominal plates with the hooks:
 - First ventral hook, as it opens the sting chamber;

- Then dorsal hook (picking up the sting) which depresses the valve fold.
- Insert the semen directly into the median oviduct with the syringe and bypass the valve fold.
- The tip of the syringe must be about 1 to 1,5 mm inserted and release slowly 8 – 10 μ l sperm per queen. If there is a reflux of liquid, correct the position of the syringe.
- Withdraw the syringe, remove first the dorsal, then the ventral hook (opposite way).
- Remove the queen from the queen holder, mark and clip her when still anesthetised.
- Place the instrumentally inseminated queen in the *apidea*® with queen excluder closed at the entrance.
- The queen is ready in about two days after insemination.
- Check after one week if the queen is egg laying.

6. Disadvantage of instrumental insemination

- Maintenance of drone supply in abundance;
- High costs of equipment;
- Materials needed at laboratory standards;
- Skilled and trained beekeeper(s) needed;
- For one queen, sperm from about eight drones are used, compared to open mating with about 18 drones;
- Sperm is stored at ambient temperature (16°C) with reduces its viability; and
- Storage of sperm in nitrogen is not yet successful.

7. Record keeping

- Records should be able to trace back the origin of the drones used, the origin and destination of the queens; the origin and destination of worker bees used for each *apidea*® as well as the origin and date of feeding; and
- The date of instrumental insemination.

- Good laboratory practice requires records on cleaning and disinfection of equipment and tools used, handling, storage, origin, and the destination of intermediate products such as CO₂ source, saline solution, etc.

B. Evaluation of maturation of drones

During the 2022 bee season, during routine hive inspections, I evaluated the maturation of a number of drones by everting the endophallus.

- A very first sensation is that drones do not sting. This facilitates the easy handling of drones.
- For the partial eversion, it was necessary to exercise on a few drones before having the technique under control. It is important to put gently but with sufficient pressure on the thorax for the endophallus to partially evert.
- Once partially everted, the colour of the cornua is indicative for having a mature or a too-young young drone at hand. As the drones were not marked, it was impossible to estimate the age of the mature drones.
- Thereafter, an increased pressure from anterior to posterior will cause a total eversion.
- Below are two pictures from a mature and immature drone taken at my apiary in 2022.



Immature drone

white coloured cornua



Mature drone

yellow-orange coloured cornua

C. My first experience with instrumental insemination of honey bees at Apimondia 2022

During the world bee congress Apimondia, which took place in Istanbul in August 2022, training was supplied by a one supplier of equipment for instrumental insemination and his assistant.

An apparatus for instrumental insemination of honey bees was set up. We were shown a simulation exercise with a focus on placing the queen at the right position in the queen holder and to open the queens' sting chamber with the ventral and dorsal hooks.

The queen is placed in a cupholder, then firmly blown through a small hole in a second queen cupholder with its abdomen popping out of the tube. This tube is then placed in situ at a right angle (*direction 'two o'clock'*) on the queen holder and the anterior end is connected to the CO₂ source.

The abdomen is just far enough exposed (last segments) at the exterior end. With the help of microscopic magnification, the ventral hook is then first placed, which opens the sting chamber ventrally and straighten the stings up. The dorsal hook has been modified by the supplier to facilitate the movement of the sting backwards. The syringed-based modification allows inserting the semen directly in the median oviduct and bypasses the valve fold. As mentioned in the introduction in section 3 above, the shape of the hook on the sting side of the chamber is critical.

Good light, a right angle of the queen holder and microscopic precision work are essential.

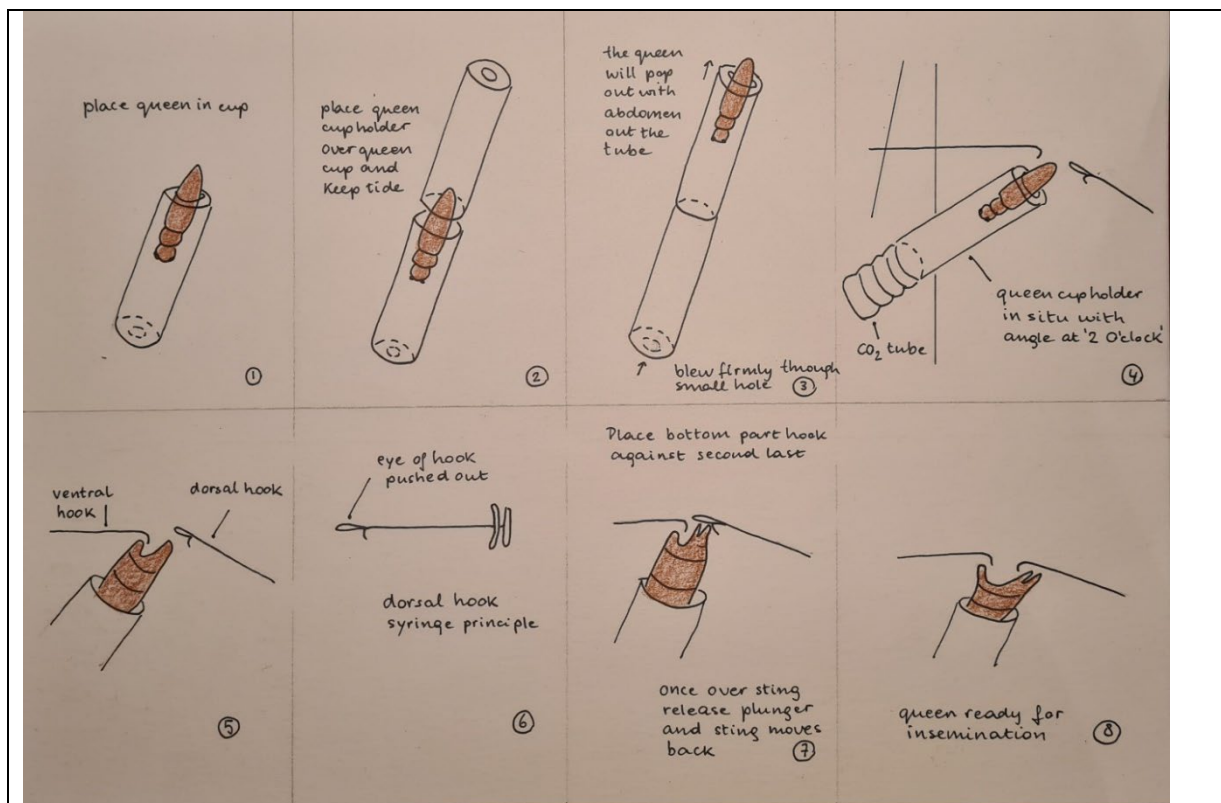
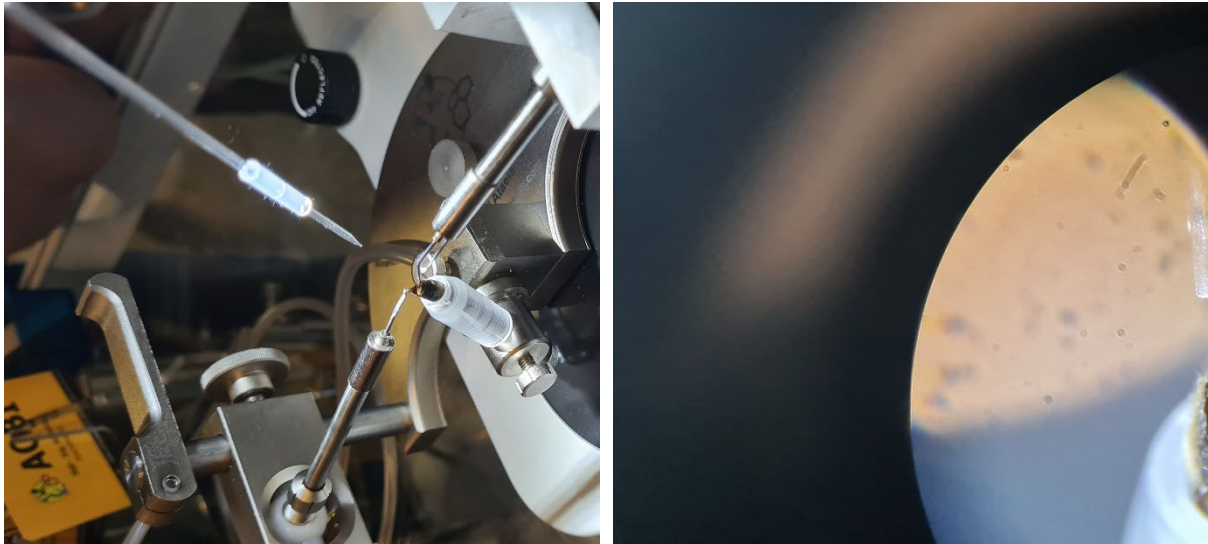


Diagram: preparing the queen



Ventral hook placed, dorsal hook is being brought into position

D. Lessons learned

My experience with the use of instrumental insemination is only a small part of the entire insemination process of honey bees. Instrumental insemination requires knowledge and skills such as the assembling of the insemination syringe, collection of sperm, the insemination of sperm, the anesthesia of the queen, use with CO₂ at the right doses, cleaning and disinfection of equipment, general problems which may occur during insemination, follow-up of inseminated queens, etc.

During Apimondia 2022 a few lectures were provided regarding bee health and instrumental insemination. Updated literature, other than scientific reports are limited available for beekeepers who wish to acquaint knowledge or to practice instrumental insemination.

E. Recommendations

1. Providing a lecture on instrumental insemination reflecting updated information on current knowledge and practices.

8.4 APPENDIX 4 – REPORT ON DONEGAL BEES STEM WORKSHOP

Report on Donegal Bees (Glencolumbkille) STEM workshop.

I attended the afternoon group visit of Donegal Bees facilities on the 9/4/22. We met up in An Cistin in Glencolumbkille and after a lovely lunch. Thomas from

Donegal Bees presented each of us with a goodie bag which contained marking pens, queen cages, honey filter cloths and blocks of Donegal Bees wax etc. We got a bus from An Cistin up the mountain to the main timber manufacturing facility. The timber Thomas uses is mainly imported as the quality of the Irish

timber is not ideal as it contains a lot of knots and often is warped. Due to the exceptionally remote location of the timber facility the timber has to be unloaded in the village and carried up the mountain by forklifts as the Lorries cannot navigate the very small bendy roads. Inside the building we saw to stacks of timber waiting to go into production, Thomas explained that every piece/plank of timber is planned out to get the most beehive products out of it and minimise any waste. In the main cutting room we saw all the saws and machine tools required with dozens of jigs and fixtures required to make the timber products. We heard that once set up on one of the components of the timber boxes that hundreds if not thousands of them are run off to maximise efficiency and keep costs to the customer down. In the next building we saw the guillotine that is used to cut up the mesh for the mesh floors, this room is also used for storage and dozens of hive stands were stored here along with various other timber parts of beehives. We then got a tour of the main timber assembly area and again heard that hundreds of the same sections of the beehive were assembled at the one time i.e. once set up to assemble supers, hundreds of supers were assembled to again maximise efficiency. Thomas told us about the galvanised sheet metal used to make the roofs and how the corners are folded in a particular way and not cut so that no water ingress can occur and that the rainwater is directed down and away from the roof. Thomas then told us about his varroa floor and how his floor is higher than other manufactures' floors, he keeps his correx insert screen well below the mesh floor at 90mm below as he told us the varroa mite can easily jump 50-60mm and make their way back up to the bees after falling through the mesh floor.

We then got back on the bus and made our way to the wax processing facility and Thomas explained that the timber and wax operations could not be near each other as the dust from the timber manufacturing would contaminate the wax. The wax facility is also the main shop and I was amazed at the huge

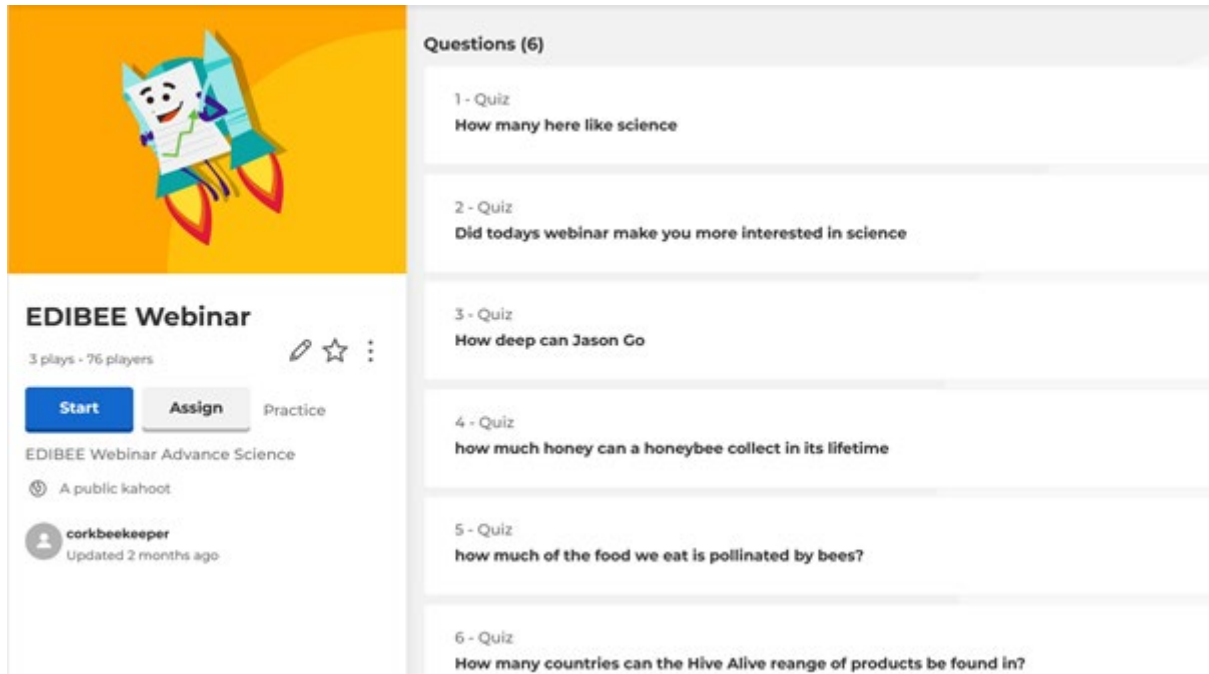
amount of stocked item that Donegal bees have and it was fascinating to see all the hundreds of floors followed by hundreds of components of bee boxes,

bee suits, wax products and wax moulds, treatments and feeds etc. Nearly every item in the Donegal Bee catalogue was here except for the poly items which were in another facility. It was a Santa's grotto for the beekeeper! We then moved onto the wax processing area and saw the huge pile of clean wax waiting to be processed and heard how Thomas buys the wax needed from Irish beekeepers and how they get paid. The big molten tank of wax heats the unprocessed wax to 140 degrees Celsius for 3 hours and then down to 85-90 degrees for a further 4 hours. Donegal Bees do not use any chemicals in the wax processing and there is various filters and baffles in the tank to filter out any debris. The molten wax is then transported to the sheet foundation production room and is stored in 2 huge heated storage tanks one for each of the 2 wax foundation producing machines . One of the machines was in production on the day and we all saw how the molten wax is picked from a molten wax bath up by a chilled roller off of which a continuous sheet of wax is produced. The wax sheet is then fed into the wax embossing machine which embosses the hexagon shape into the wax by squeezing it between 2 lubricated embossing rollers. Once embossed it is cut into the required size. It takes 2 people to keep the machine going. These wax sheets of foundation are then sent to the area where the wire is embedded into the wax sheets. The sheet of wax is placed in a fixture and then the wire to be embedded is fed around various pins to form the "W" shape on top of the wax sheet. An electrical charge is then applied to the wire by the operator which heats the wire. The wire then sinks into the wax. I found this to be most interesting and spent a long while watching as it cannot be automated but must be done by the experience and feel of the operator. Too much heat and the wax surrounding the wire melts away too little and the wire does not get embedded properly.

Overall I was very impressed with the sheer scale of the business and the amount and quantity of products in stock. Thomas spoke in detail about various products and aspects of the business and answered all questions. I was most impressed with the wax side of the operation and how it is Irish wax for Irish Beekeepers and we should use it more! I thoroughly enjoyed the day.

8.5 APPENDIX 5 – KAHOOT! SCREENSHOT

Screenshot of using Kahoot! engagement at Advance Science STEM Workshop



The screenshot displays a Kahoot! quiz interface. On the left, the quiz title is "EDIBEE Webinar" with 3 plays and 76 players. It includes buttons for "Start", "Assign", and "Practice". The quiz is described as "EDIBEE Webinar Advance Science", is a public kahoot, and was updated 2 months ago by the user "corkbeekeeper". The main area on the right lists six questions:

- 1 - Quiz: How many here like science
- 2 - Quiz: Did todays webinar make you more interested in science
- 3 - Quiz: How deep can Jason Go
- 4 - Quiz: how much honey can a honeybee collect in its lifetime
- 5 - Quiz: how much of the food we eat is pollinated by bees?
- 6 - Quiz: How many countries can the Hive Alive reange of products be found in?

8.6 APPENDIX 6 – YOUTUBE ENGAGEMENT

Screen shot of the analytics of the EDIBEE YouTube page (January 2023).

