SABIO
SOUTH AFRICAN BEE INDUSTRY ORGANIZATION
100 YEARS
1921-2021

The South African Bee Journal

November 2021 • Volume 93 • No.3

BIOLOGY OF DRONES

SUCCESS OF THE DECENTRALISED BEECON 2021

RECOMMENDED RETAIL PRICE: R40
ISSN 0038-2019
9 770038 201007

The South African
Bee Journal
July 2021 • Vol. 93 • No. 2

EMAIL

SABJeditor@gmail.com

Layout and Design

Alastair Crewe
alastaircrewe@gmail.com

DISCLAIMER

CONTACT

SABIO Website:
www.sabio.org.za

General Enquiries:
info@sabio.org.za

Membership, insurance and Administration:
admin@sabio.org.za

CONTENTS

Cover Image: Drone mating with a tethered queen. Historic picture of drone mating taken by Dr. Gudrun Koeniger. © Gudrun Koeniger

SABIO is the official representative of the bee industry of South Africa. Its mission is to "represent and promote the interests of all persons involved in the beekeeping industry in South Africa in order to establish, support and develop an economically viable and sustainable apicultural sector and ensure the environmental security of the honey bee".

Editorial

We reach the end of the year with some positive news and also some looming threats to the beekeeping industry. On the positive side, the idea of holding a decentralised BEECON so that a variety of beekeepers could attend the functions turned out to be highly successful. The various meetings attracted a large number of beekeepers in each of the regions where it was held. The details of these meetings and their success is illustrated in a report of the meetings that is contained in this issue.

The challenges that beekeepers face are significant and need to be addressed through collective action and lobbying of authorities who have the power to mitigate some of the risks. This will provide for a vibrant industry that supports agricultural production and livelihoods. This issue was recently addressed by SarahBelle Selig who reviewed some of the issues facing the industry that on the surface appears to be growing significantly in numbers of beekeepers[1]. However despite the growth, she points to a number of issues that need to be addressed. Here are some of the factors that lurk in the undergrowth to catch the unwary beekeeper by surprise:

1) Apart from the registration of beekeepers (used to measure the growth of the industry), a standard curriculum for a qualified beekeeper needs to be developed so that individuals have sufficient knowledge of the basic biology of bees to keep bees colonies sustainably. In addition, the curriculum should introduce beekeepers to the requirements for honey production, pollination and the management of a beekeeping operation. In addition to the taught material, the prospective beekeeper should be required to work for at least six months under the mentorship of a qualified beekeeper. Registration of beekeepers should be in two categories – candidate beekeepers who are novices starting out, and qualified beekeepers who have successfully completed the recognised course for training in beekeeping and can demonstrate their expertise. Those without any qualifications should be prohibited from keeping honey bees.

2) Suitable apiary sites: Beekeepers are largely dependent on relationships with land owners in order to find and get access to suitable sites for apiaries. These sites are not necessarily readily available and can serve as a bottleneck for an aspiring beekeeper.

3) Bee forage: The removal of eucalyptus trees and forests had a strongly deleterious effect on the availability of bee forage and hence the ability to maintain colonies in large numbers. This was one of the main unintended consequences of the Working for Water Program and the damage that was done needs to be reversed by providing incentives to establish vegetation that can support bee colonies by providing reliable forage. The exploration of South Africa's various biomes needs to be undertaken to determine where wild colony density is the highest and the likelihood of survival of colonies in apiaries can be assured. Our understanding of the state and size of the wild population of honey bees is hopelessly inadequate and makes planning for a sustainable beekeeping industry almost impossible.

4) Government support for beekeeping: Although the Department of Agriculture, Land Reform and Rural Development has a section that deals with the honey bee industry it is hopelessly too small and bedevilled by the fact that delivery has to take place via provincial departments that vary widely in attention to this matter. There is a strong case to made for a unified approach to the industry from all the provinces guided by the national department. Considering the importance of honey bees for agricultural, and for rural development this deserves more attention. The establishment of an Apicultural Advisory Committee by DALRRD in conjunction with SABIO would be a helpful step in co-ordinating approaches to beekeeping across the country.

5) Honey bee research: Most successful industries maintain a level of research that enables them to be able to respond to changes in their environment and to ensure that they are able to respond to future changes or shocks. Research on honey bees and bee products has dwindled alarmingly over the last three decades, and although there is 'in kind' support from the industry, there has been little direct investment in research work. What research is done is being pursued by individuals who source their research funds from sources independent of the industry or of DALRRD. This is a situation that needs to be rectified in the interest of food security and the maintenance of healthy biodiversity.

The factors that I have listed above can be thought of as those that beekeepers need to manage in order to be able to have viable businesses. However, there are other factors related to the behaviour of beekeepers and other human actors that need to be equally forcefully managed if they are not to undermine the beekeeping industry and threaten food security. These factors are:

1) Honey fraud – this comes in a number of forms such as passing off sugar syrup as honey, adulterating honey with sugar syrup to increase yields, providing misleading information about the origin and quality of honey that is sold.

1. URL https://www.iol.co.za/business-report/economy/analysis-sas-beekeeping-is-up-400-but-is-it-still-poised-to-fail-703089cb-524b-4d7d-8e4b-eadc68588cc9

"Laundering" honey from one region through another in order to artificially raise prices. Harvesting unripe honey and then processing it to reduce the water content. All of these activities undermine the integrity of locally produced honey varieties and undermine the market.

2) Theft -with the increased demand for colonies for use in honey production and pollination, there has been an increase in the theft of colonies and even whole apiaries by beekeepers. This is criminal behaviour that needs to be stopped.

3) Vandalism – this occurs in apiaries where colonies are vandalised and the honey and or brood is removed from the colonies and stolen. Not only is this a loss of production to the beekeeper, but it also incurs significant costs in replacing damaged equipment and sourcing new bee swarms.

These factors are characterised by a complete lack of ethical behaviour on the part of the individuals participating in the activities, largely driven by any lack of consequences for behaving in this way. Consequence management should be actively pursued by DALRRD inspectors in relation to the application of the regulations regarding the production of fraudulent honey. In addition, SAPS should be undertaking thorough investigations of theft and vandalism and the perpetrators should be caught and receive the appropriate punishment.

Finally, the beekeeping industry itself should police those of its members who participate in activities that bring the industry into disrepute. Establishing and requiring its members to adhere to a code of ethical conduct that everyone respects would be a good place to start.

Robin Crewe
8 November 2021

agriculture, land reform & rural development
Department: Agriculture, Land Reform and Rural Development
REPUBLIC OF SOUTH AFRICA

CONTACTS FOR BEEKEEPING

Mr Riaan van Zyl and Mr Kobus Kemp are the persons who beekeepers should contact If they have any suspicion about bee diseases or the presence there of such as AFB and the Capensis clones.

They can also be contacted regarding legislation concerning honey labelling and the standards of import requirements of honey.

They do not provide advice on beekeeping practises, but will if possible direct persons with enquiries to the correct or experienced sources.

PLEASE CONTACT THEM:
Riaan van Zyl: (Capensis)
Tel: 021 809 1702
Cell:083 4142494
Email: riaanvz@dalrrd.gov.za

Kobus Kemp: (Scutellata)
Tel: 012 309 8762
Cell:082 873 1678
Email: kobusk@ dalrrd.gov.za

SABIO Chairperson's Report AGM 5 September 2021

By: Aadrian du Toit (Chairperson)

HIGHLIGHTS OF THE LAST YEAR

Travel permits during lockdown

Last year about 120 permits were issued by SABIO and an unknown number by the associations. Permits really assisted those who made use of the SABIO permit when travelling during curfew hours as well as crossings provincial borders. No come-backs or problems on the road were reported. This activity took a lot of time for us all to process the applications and issue permits.

Bee Journal

The Editorial team diligently continued publishing the Bee Journal. This is one of our largest cost items on the financial statements, although some issues have been sponsored. It was disappointing that distribution was disrupted due to the postal service being affected by COVID-19, with the result that no post went out. The real frustration was that journals did not reach members in good time or not at all. The Editorial committee will be stepping down at the end of the year as their term will come to an end and the Chief Editor, Prof Crewe is moving to the Eastern Cape.

Board Meetings & AGM

These were disrupted by Covid-19. Travel was not easy especially air travel. The last two meetings that could be held on-site were in January and May 2021. Zoom meetings were held in between to discuss specific activities. The 2020 AGM could only be held in November 2020 at the time of the national honey show.

Honey Fraud Symposium

This was planned and held as a virtual event on 20 May 2021, World Bee day. In all, 620 people registered for the conference showing a wide range of interest from beekeepers, bottlers, retailers and traders, consumers, test houses, food safety auditing bodies and auditors as well as academia. In terms of honey quality awareness, it was one of the most important interventions organised by SABIO in a long time. We saw product labels changing very quickly right after the symposium.

Beecon Roadshow 2021

See separate report in this journal.

PLANNED ACTIVITIES

1. **Apimondia** (International Apicultural Congress)

The next Apimondia International Congress to be held in Russia was postponed to 2022 due to Covid-19. SABIO is planning to apply and bid to host the 2027 congress in South Africa. To enhance our chances of being successful, it is vital for our beekeepers to attend all upcoming Apimondia conferences to be seen and noticed. I would like to appeal to beekeepers to attend the next congress in Russia (5-10 September 2022 – also see announcement elsewhere in this journal) so that we can make an impact and statement. Apimondia congresses in Europe are huge with 20 000 – 25 000 participants, much bigger than the biggest conference of any kind held in South Africa.

SABIO will have to present its bid presentation in 2023 in Chile. South Africa stands a good chance of winning the bid, especially if Africa is designated as one of the preferred host regions, but we cannot do this without the backing of government. SA Tourism is responsible for conference bid support and the SABIO Board has a good relationship with them.

2. BEECON 2023

This will probably be hosted in the Western Cape Province and we are awaiting a decision from the Cape Bee Industry Association. In the short term, SABIO wants to take BEECON to less well-represented provinces, specifically where no BEECON has been hosted before. This could create the potential of neglecting SABIO's bigger membership base. I do believe we can mitigate this risk by hosting field days at a regional level to maintain SABIO's visibility.

3. Creating new partnerships

I believe the SABIO Board should engage different government agencies with funding available and request them to inform us of their offerings. The Board should come up with a strategy to work with these entities to improve compliance with bee regulations and insure that the industry is supported.

MATTERS AFFECTING THE INDUSTRY

The following matters affecting the beekeeping industry will need attention in the immediate future: 1) AFB (American Foulbrood) It is critical to look at possible outbreaks and concerns about reports of overdosing with antibiotics as a beehive treatment. 2. Honey Fraud There is still a lot of work to be done in terms of awareness and education. Nonetheless, we achieved a high level of awareness through the honey fraud symposium. 3. Self-Regulation Government does not have the capacity to police everyone and expects the industry to be self-regulating. 4. Theft and vandalism The Chairman proposed that beekeepers should register with the farm security firms at a local level and be involved with them, but as beekeepers, we should also look out for one another. Dr Tlou Chokoe, DALRRD, Directorate: Genetic Resources commented that at both International and National levels bees have been declared to be farm animals so the stealing of beehives is now regarded as stock theft. This is the best opportunity to get assistance from FAO, AUIBA, SADC and our government. Now it is a mandate, the Department is required to assist beekeepers. Mrs Salamina Maelane, DALRRD, Directorate: Food Safety further commented that the Department had a meeting with the acting Deputy Director-General who confirmed the classification of bees as livestock. We need to drive an awareness campaign in partnership with SAPS and rural safety initiatives to ensure that this is understood by all participants.

ACKNOWLEDGEMENT

The chairman acknowledged Mrs Salamina Maelane's contribution to the industry over the past 10 years. She is advancing in her career and has been appointed as the Agricultural Attaché at the EU in the Brussels office.

DO YOU WANT TO KEEP BEES?

JOIN THE SOUTHERNS BEEKEEPING ASSOCIATION

- Monthly meetings in Bryanston.
- Experienced beekeepers to advise you.
- Field trips for practical experience.
- Honey Competitions!

www.beekeepers.co.za
info@beekeepers.co.za

SBA

SOUTHERNS BEEKEEPING ASSOCIATION

@SouthernsBeekeepingAssociation (Facebook)

Report from BEECON 2021

In celebration of the South African Beekeeping Industry's centenary year, the annual SABIO BEECON which focussed on macadamia pollination, was held at six different venues rather than just the usual one location. This was both in response to the national state of emergency due to the COVID-19 lockdown regulations and in order to meet beekeepers in as many areas (previously uncovered by national beekeeping conferences) as possible. Thus, essentially taking BEECON to the beekeepers and farmers alike. In further response to the hardships brought on by the current pandemic, we were able to make attendance free to all delegates (macadamia growers, SABIO members and non-members alike) due to our generous event partner and sponsors. The response was overwhelming as we reached far more than our anticipated audience with around 450 delegates attending these six events. Therefore following the very well attended and successful conferences, we would like to thank our Event Partner and the following Sponsors for their generous contributions that made it possible for us to host this event in 6 locations without charging any fees to any of the attending delegates:

The program at each venue between 12 August and 3 September 2021 included a well-rounded approach to pollination of Macadamia orchards and how growers could best protect the pollinators needed to maximise fruit set with the following topics presented by experienced speakers:

THE EFFECT OF HONEY BEE POLLINATION ON CROP YIELD – DR HANNELIE HUMAN (RESEARCHER, SIRG, UNIVERSITY OF PRETORIA)

ENVIRONMENTALLY FRIENDLY MANAGEMENTOF MACADAMIA PESTS: CAN ITBE ACHIEVED? -DR SCHALK SCHOEMAN (RESEARCH EXTENSION MANAGER AT SAMAC)

MAXIMISING POLLINATION IN MACADAMIA -MICHEL LENFERNA (BEEKEEPER: FORMER POLLINATION SERVICE PROVIDER)

ADDITIONAL FORAGE TO SUSTAIN POLLINATORS AND BEE POPULATIONS TO MAXIMISE POLLINATION - DR ADRIAAN DU TOIT - CHAIRMAN OF SABIO

Numerous growers and beekeepers contacted individual speakers and organisers after the event thanking us for the information received and asking for more in-depth questions. This was truly a ground breaking series of events that reached more people than we anticipated considering the current lock down situation in South Africa. So many more will be reached continuously in years to come through the videos that will remain in the **SABIO** and **BEECON** websites. The valuable information shared will be freely available to all thanks to the generosity of our sponsors.

Some photos of the different events are as follows:

East London: Hosted by **Ncera Macadamia Farming** on 12 August 2021

Dr Schalk Schoeman speaking at Ncera Macadamia Farm on 12 August 2021

Dr Adriaan du Toit addressing delegates at Ncera Macadamia farm on 12 August 2021

Port Shepstone: Hosted by **Paddock Farmers Club** 17 August 2021

Due to the weather forecast of more rain, the meeting took place inside the Paddock Farmers Club Hall which is thankfully very large and open with French doors. Proper social distancing and protocols were employed and all delegates had a very informative and interactive day. Several of our sponsors had tables and banners at this event.

Entrance to the venue for the meeting on 17 August 2021

Our Platinum sponsor Ford displayed some of their vehicles

Our Platinum sponsor Ford displayed some of their vehicles

Dr Schalk Schoeman addressing the delegates in Paddock on 17 August 2021

The event was well attended by KZN growers, beekeepers and development beekeepers from as far afield as Mthatha. Macadamia Pollination is in it's infancy in this province and most delegates commented on the wealth of information received.

Michel Lenferna and Dr Adriaan du Toit in a question and answer session at Paddock

Delegates perusing the information shared shortly after a break

Mtubatuba 19 August 2021: Our Host **William Davidson**
This venue was a large very open shed that our host made available for the event.

Delegates enjoying coffee before the event started on 19 August 2021

Beekeeper Michel Lenferna presenting the topic Maximising Pollination in Macadamia

Dr Adriaan du Toit speaking to delegates at the Mtubatuba meeting on 19 August 2021

Zululand development beekeepers meeting with one of the speakers Inge Lotter discussing what they have heard

Tzaneen hosted by **Amorentia Estate & Nursery** on 24 August 2021

Setting up the reception area on the beautiful Amorentia Estate on the 24th of August 2021

The Tzaneen meeting took place on a hot day in the shade of an imposing Matumi tree -one of the three largest of its kind in South Africa.

Dr Adriaan du Toit addressing the delegates in the woods of the Amorentia estate

Dr Hannelie Human sharing the results of her ground breaking study done on the effect of honey bee pollination on macadamia crop yield

Levubu hosted by **Bruce Milton** of **Teaklands Farm** on 26 August 2021

This event was attended by many growers and beekeepers as well as development beekeepers in this very established area of macadamia production. Much of the information shared was however new and of great value to the delegates.

Ford Wildlife, our platinum sponsor shared info about their Lapalala project

The open air shed next to the macadamia orchard was a perfect venue for the event at Levubu

Dr Hannelie Human sharing the results of her study with the delegates at Levubu

Dr Schalk Schoeman speaking to the delegates about environmentally friendly pest management principles

Inge Lotter sharing information about hive management techniques using bee nutrition

A hearty lunch of Boerewors Rolls were enjoyed at each event.
At Levubu delegates tuck in amongst the macadamia trees

Nelspruit: Hosted by **Broham Lapa** on 3 September 2021

The final and main event was held near Nelspruit in two groups due to the number of delegates that attended as per the COVID lock down limitations. One group attended the presentations under the trees at the camping area and the other inside the Lapa with the speakers presenting in both locations. The event was well attended by growers, beekeepers and development beekeepers of this established macadamia growing area. Many delegates voiced their appreciation of the knowledge gained through the well-rounded presentations. Subsequent to the events many growers and beekeepers have called the organisers to congratulate them as they have noticed changes in pesticide management within their community which is a direct spin off from these events.

Registration area ready for the arrival of delegates at the final and main Nelspruit event held at Broham Lapa on 3 September 2021

Beekeeper Michel Lenferna sharing his knowledge on honey bee pollination in Macadamia orchards under the trees at Broham Lapa

Dr Schalk Schoeman sharing ways to minimise environmental damage during pest management on macadamia orchards to the group attending the open air presentation in the shade of trees at the Broham Lapa

Beekeeper Michel Lenferna addressing the attendees within the Borham Lapa building

The group of beekeepers and growers attending presentations inside the Broham Lapa building waiting for the presentation to begin

Dr Schalk Schoeman addressing the group of delegates inside the Broham Lapa building

Dr Adriaan duToit presenting ways to increase bee nutrition by planting bee forage and through artificial feeding

Dr Hannelie Human sharing her ground breaking results from the study on the effect of honey bee pollination on macadamia crop yield

Delegates listening intently to the presentation by Dr Hannelie Human

These events would not have been possible without the generous financial support received from our event parter and all our sponsors. From the beekeeping industry and macadamia growers, a vote of thanks fall far short of acknowledging the value of your contribution to this series of conferences.

The true value of the information shared and how it is implemented on the ground will only be known in some time to come, but through the freely available presentations on the **SABIO** www.sabio.org.za and **BEECON** www.beeconsabio.org.za websites and the articles that will be published in the South African Bee Journal, which is sponsored by Ford Wildlife, a huge number of beekeepers and growers will be reached for many years to come. This ground breaking event where beekeepers and growers came together will surely have a positive long term impact on the honey bee health within macadamia orchards, pollination efficiency as well as helping to mitigate the effect of pest control on the environment.

TA further sponsorship by FORD Wildlife for the South African Bee Journal's publication, will enable SABIO to distribute the 3rd edition of 2021 covering the BEECON event to all delegates of the events, whether they are SABIO members or not.

CONTACT DETAILS

NATIONAL ASSOCIATION

SABIO: South African Bee Industry Organisation
Chairman: Adriaan du Toit, Pretoria, Gauteng
Cell: 083 306 1446 * Email: info@sabio.org.za
* Web Address: https://www.sabio.org.za/

REGIONAL / LOCAL ASSOCIATIONS & INTEREST GROUPS

Eastern Highveld Beekeepers' Association
Chairman: Capie du Toit * East Rand, Gauteng
Cell: 072 368 0476 * Email: capiedutoit@absamail.co.za

Eastern Cape Mpuma-Koloni Bee Association
Secretary: Sisiphiwo Dingana
Cell: 073 715 8450* Email: dsisiphiwo@gmail.com

Knysna Beekeepers' Association
Co-ordinator: Owen Williams * Knysna, Garden Route
Cell: 078 724 6425 * Email: honeychildhoney2@gmail.com

KwaZulu-Natal Bee Farmers' Association
Chairman: Ronald Moore * Pietermaritzburg, KwaZulu- Natal
Cell: 082 552 3284 * Email: moorerandd@gmail.com

Mpumalanga Beekeeping Interest Group
Co- ordinator: Inge Lotter * Nelspruit, Mpumalanga
Cell: 082 821 5011 * Email: inge.lotter@gmail.com

Northern Cape Bee Interest Group
Co- ordinator: Douglas Bee Farms * Douglas, Northern Cape
Cell: 053 298 1101 * Email: dbf@vodamail.co.za

Northerns Beekeepers' Association
Chairman: Jan Steenkamp* Cell: 076 061 3700
Communications: Riekie van den Berg * Pretoria, Gauteng
Cell: 082 972 1889 * Email: justrie@mweb.co.za

Southern Cape Bee Industry Association
Chairman: Andre de Jager * Email: andredjager@vodamail.co.za
Co- ordinator: Hannes van Zyl * George, Southern Cape
Cell: 082 922 6756 * Email: suidkaapbye@gmail.com

Southerns Beekeeping Association
Chairman: Kai Hichert * Johannesburg, Gauteng
Cell: 082 561 0346 * Email: hichert@worldonline.co.za

Western Cape Bee Industry Association
Chairman: Brendan Ashley-Cooper * Cape Town, Western Cape
Cell: 082 484 0030 * Email: info@wkbv.co.za

Costs and Benefits Of Honey Bee Drones

By: Fiona N. Mumoki, Christian W. W. Pirk and Abdullahi A. Yusuf
Social Insects Research Group, Department of Zoology and Entomology, University of Pretoria, South Africa

Division of labour is one of the key distinguishing features of eusocial insects such as termites, bees, wasps and ants, where one or a few individuals are reproductively active while the majority of the colony members are reproductively sterile. With the exception of the termites, division of labour and reproductive asymmetry is confined to females. In the case of the honey bee Apis mellifera L., the queens and drones are the reproductive individuals while workers perform tasks related to general colony maintenance and growth (Winston 1987). Whereas the biology and tasks of the queen and workers are relatively commonly discussed, much less is said about drones, the male members of the colony. This is what we intend to briefly explore in this article.

Drones in A. mellifera colonies are reared seasonally to coincide with reproductive swarming (McNally and Schneider 1994) and in South Africa, this period typically peaks between August and October (Johannsmeier 2001) although drone rearing can extend well into late summer. Seeley (2002) showed that drone comb takes the space that would have otherwise been occupied by honey comb in colonies, with colonies that had about 20% drone comb (natural amount of A. mellifera drone comb in summer and spring) having almost 50% less honey than colonies without drone comb. Further, compared to queens and workers, drones have the longest developmental cycle and the longest periods of time spent in the uncapped larval stage. This is time that workers must spend either tending to the drone brood through feeding, cleaning or maintaining a specific temperature and humidity as opposed to gathering resources for the colony. In addition, young adult drones (newly emerged about seven days old) are fed by nurse bees through trophallaxis (Ruttner 1966), further taxing the colony's nurse bee population. Further still, little is known about the contribution of adult drones (Figure 1) to the general wellbeing and maintenance of the colony. Drones do not have a sting, hypopharyngeal glands or pollen baskets (Snodgrass 1910), thus, they cannot participate in defence, feeding or foraging activities of the colony. Given these production costs, it is thus not a surprise that colonies will generally limit drone rearing to periods of time where there is 1) high nectar and pollen availability (Boes 2010), 2) a high large population of nurse bees 3) potential queens available for mating (Lee and Winston 1987).

Figure 1: Adult Apis mellifera drone in flight. Drones leave the hive first for orientation flights while still sexually immature and mating flights upon attainment of sexual maturity.

Through a feedback mechanism, workers can regulate the number of drones that a colony can rear, by controlling the amount of drone comb constructed (Free and Williams 1975). Smaller colonies construct fewer drone cells, resulting in smaller numbers of drones while larger colonies with ample resources construct plenty of drone cells ensuring more drones will be present (Boes 2010; Lee and Winston 1987). Ranging between 6.0 mm to 6.4 mm, A. mellifera drone cells are larger than worker cells (4.8 mm to 4. 9 mm) and are usually found in the lower parts of the frames, with drone cells from African honey bees known to be smaller than those of their European counterparts (Hepburn et al. 2014).

During periods of high nectar flow, workers construct worker and drone brood cells and the queen lays unfertilised haploid eggs in the drone cells. Three days later, the egg transitions into a larva and will spend about 6-7 days in this stage. Drones spend more time in this larval stage, compared to both queens and workers (which take 4-5 days) and will be fed more food per cell as compared to worker cells (9.6 mg vs 1.7 mg for workers) (Planta 1888), emphasising the relative cost implications of rearing drones. Larval nutrition is provided by nurse bees who secrete "jelly" through their well-developed hypopharyngeal (Lindauer 1952) and mandibular (Schiemenz 1883; Callow et al. 1959) glands. Drone brood is fed on drone jelly which is thought to be similar in composition to worker jelly (Haydak 1970; Haydak 1957). About 10 days after the egg was laid, the drone cell is capped by the workers, marking the start of the transition of the larvae to pupae and 24 days post-egg laying, the adult drone emerges (Winston 1987) (Figure 2).

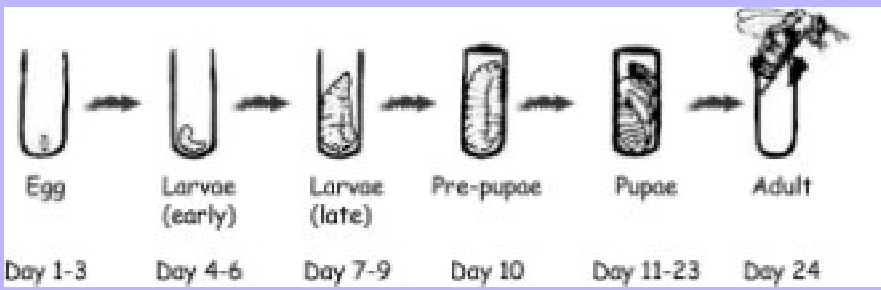

Figure 2: Lifecycle of A. mellifera drone. The haploid egg transitions into early-stage larvae, late-stage larvae, the recently capped pre-pupae, pupae and finally emerges as an adult drone in about 24 days. Various intermediate stages of larval and pupal development have not been shown in this diagram. (Modified from Winston 1987)

Young drones (less than seven days post-emergence and also known as "hive drones") are fed modified drone jelly (mDJ) by the nurse bees (Haydak 1957; Haydak 1970). This consists of drone jelly, with an addition of pollen, as a source of protein for the drones. Usually, the drones at this age are typically found in the central parts of the comb, (near the nurse workers who tend the brood), hoping to get fed by these workers through trophallaxis (Ohtani and Fukuda 1977). It is also thought that the temperature of the brood comb (~35 °C) is high enough to accelerate sperm maturation (Mindt 1962).

At around seven and eight days old, the drones, still sexually immature, start leaving the hives on orientation flights (Ruttner 1966; Howell and Usinger 1933; Reyes et al. 2019). During these flights, the drones learn where the hives are and also memorize landmarks, in relation to other colonies and any nearby drone congregation areas (DCAs) (Currie 1987). At this time, the drones also start to feed themselves on honey (Ohtani 1974) to obtain energy crucial for sustaining the orientation flights (and later for the mating flights), and can be found, most times, near the honey reserves (Haydak 1970). Orientation flights take place in the early afternoons especially in Spring, from 14:00 hrs to around 16:00 hrs. The drones make multiple short flights, returning to the hives and then flying back out again. Individual drones can make numerous orientation flights per day (Currie 1987; Howell and Usinger 1933; Lensky et al. 1985; Reyes et al. 2019).

Sexual maturity is thought to be reached at around 12-14 days old although this may vary by subspecies and season (Reyes et al. 2019). Mature drones take part in mating flights which, are longer than the orientation ones (Reyes et al. 2019; Howell and Usinger 1933; Ruttner 1966). Sexually mature drones congregate in Drone Congregation areas (DCAs), waiting for a chance to mate on the wing, with virgin queens (Figure 3 A & B). These congregation areas contain mixed populations of drones from many colonies and from several nearby apiaries. In fact, Baudry et al. (1998) showed that a DCA in Austria was host to drones from about 240 different colonies, and that majority of the drones present in that DCA were unrelated to each other, while Moritz et al. (2007) showed that drones collected from DCAs in Ezemvelo, Leeuwfontein and Suikerbosrand in South Africa, represented as many as 44, 32 and 43 independent colonies, respectively.

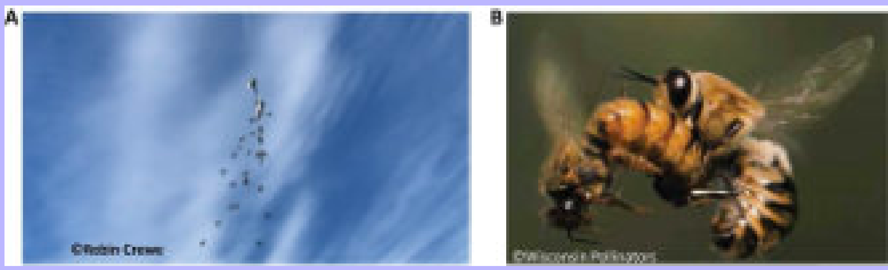

Figure 3: Drones perceive and pursue the virgin queens based on both visual and olfaction cues as shown by the drone comet pursuing the queen pheromone lure containing the queen pheromone 9-ODA (3A), at a drone congregation area in Port Alfred, South Africa. Mating takes place on the wing with the drone approaching the virgin queen from below (3B).

Once a virgin queen passes near the DCAs, the drones in the area quickly orientate their bodies in attraction to the queen (Gries and Koeniger 1996), perceiving her using a combination of olfactory (Gary 1962) and visual cues (Vallet and Coles 1993). Olfaction is the first way in which the drones will perceive the virgin queen. While still quite a distance off, the virgin queen secretes pheromone signals, particularly those from the mandibular glands which contain the pheromone components such as 9-keto-2 (E)-decenoic acid (9-ODA) (Brockmann et al. 1998; Wanner et al. 2007), which is also the major component of the virgin queen's mandibular gland repertoire (Plettner et al. 1997). This attraction of sexually mature drones to 9-ODA has also been shown in experiments where lures are dosed with queen-equivalent amounts of 9-ODA and flown near known DCAs as shown in Figure 3A.

After smelling the queen, the drones will fly quickly upwind towards the source of the 9-ODA, forming temporary swarm-like formations knowns as 'drone comets' (Figure 3A) and will then employ their excellent visual abilities to home in on the flying queen. A huge proportion of the drone head consists of eyes; two large compound eyes placed on opposite sides of the head and three large frontal ocelli (Snodgrass 1910; Streinzer et al. 2013). The drones will typically approach the virgin queen from below, possibly to maximise vision using the large dorsally placed compound eyes (Menzel et al. 1991).

The first drone that reaches the queen grasps her with all his legs (Figure 3B) and everts the endophallus into the queen's open sting chamber. A rapid and explosive ejaculation follows, causing the everted endophallus to rapture and pushing the semen through the sting chamber into the queen's oviduct. The ejaculation also separates the drone and the queen. With the rapturing of his abdomen, the drone dies soon after, leaving part of the endophallus and coagulating mucus still attached to the queen's sting chamber. This plug, also known as a "mating sign' (Woyke and Ruttner 1958), does not prevent other drones from mating with the queen (Parker 1970). Its presence facilitates further mating by protecting the endophallus of the following drone, against the queen's stinger (Koeniger 1986) and also prevents semen from flowing out (Woyciechowski et al. 1994). The whole mating process takes place in less than 5 seconds from the point of initial contact between the queen and drone (Woyke and Ruttner 1958; Koeniger et al. 1979; Winston 1987). Virgin queens are polyandrous and mate with multiple drones during a number of mating flights (Neumann et al. 1999; Woyke 1964). Queens mate with as many as 56 drones as is the case with A. m. capensis queens (Kraus et al. 2004). Once the mating activities are completed, the mated queen will return to the hive where she will begin the process of transferring sperm from the oviduct to the spermatheca and start the process of egg laying (Winston 1987). In this process, she will expel more than 97% of the ejaculate received from the drones on the mating flights, with only about 3-5% of the sperm obtained per done being stored in the spermatheca (Koeniger and Koeniger 2000) where the sperm will remain viable for the lifetime of the queen (Tarpy et al. 2012).

As the nectar and pollen flow starts dwindling with seasonal and climatic changes, the queen starts reducing the number of eggs laid, and the workers start preparing the colony for harsher conditions. This preparation will also involves the removal from the colony of all the drones that were unsuccessful in mating. These drones are typically prevented from feeding by the workers, leaving them to die of starvation. Other drones are simply violently removed from the colony by the workers, and it is not uncommon to find drones stuck at the entrance of the colony where they have been refused entry, or, simply, drones dead at the entrance to the hive, at the close of the spring and summer months.

Given the costly nature of rearing drones and the fact that mated drones die soon after mating, while the ones that fail to mate are chased away from the host colonies once resources start to dwindle, one is left wondering why honey bee workers would commit expensive colony resources including energy, space, and food to rear drones. What is the advantage of this type of social structure? What are the benefits of polyandry, given that multiple mating by the queen increases the genetic diversity in the worker population, but also leads to reduced benefits of altruism due to low within-colony relatedness?

Mattila and Seeley (2007) carried out elegant experiments to examine the fitness and productivity of colonies headed by queens instrumentally inseminated with sperm from multiple drones (genetically diverse colonies) and those of queens instrumentally inseminated with sperm from a single drone (genetically uniform colonies). For both groups, insemination was carried out using the same volume of sperm and were given the same number of workers from a similar genetic pool, with which to begin new colonies. They showed that having increased genetic diversity in a colony confers numerous benefits on colonies. The genetically diverse colonies built more comb, produced more workers and at a faster rate, showed higher foraging activity and stored more hive resources as compared to their genetically uniform counterparts. Further, these colonies grew in size faster than their counterparts and were better able to survive winter conditions. All the genetically uniform colonies died of cold and starvation less than a year after they were established. Similar research has shown that genetically diverse colonies have a higher resistance to infections such as the American foulbrood disease (AFB) caused by the highly-virulent Paenibacillus larvae (Seeley and Tarpy 2007; Mattila et al. 2012), more efficient worker-worker waggle dance communication leading to better exploitation of food resources (Mattila et al. 2008), higher colony survivorship (Tarpy et al. 2013), greater microbial diversity especially that of beneficial bacteria such as those of the probiotic genus Bifidobacterium (Mattila et al. 2012) and better within-colony thermoregulation (Jones et al. 2004).

Apart from increased fitness of the genetically diverse colonies, workers in queenless colonies sometimes get the opportunity to lay eggs and have their sister workers rear drones from them. Thus, rearing drones laid from workers' eggs is the only way in which individual workers can achieve any kind of reproductive success (Utaipanon et al. 2019). While the contribution of worker reproduction is small in European honey bee colonies (Visscher 1996), the proportion of worker-laid eggs is much higher in African colonies (Moritz et al. 1998).

In this brief piece, we describe the life of Apis mellifera drones. These male members of the colony have been ignored in many studies on honey bees, with more attention given to other members of the colony; the queen, workers and brood. Thus, although drones are expensive to rear, they contribute significantly to colony-level success by providing a worker taskforce that is genetically diverse, and that the benefits of this highly diverse worker population affect most aspects of colony life ranging from enhanced colony level immunity to higher foraging ability and ultimately colony growth and survival.

References

Baudry, E, Solignac, M, Garnery, L, Gries, M, Cornuet, J & Koeniger, N 1998. Relatedness among honeybees (Apis mellifera) of a drone congregation. Proceedings of the Royal Society of London. Series B: Biological Sciences, 265, 2009-2014. http://doi.org/10.1098/ rspb.1998.0533

Boes, KE 2010. Honeybee colony drone production and maintenance in accordance with environmental factors: an interplay of queen and worker decisions. Insectes Sociaux, 57, 1-9. https://doi.org/10.1007/s00040-009-0046-9

Brockmann, A, Brückner, D & Crewe, RM 1998. The EAG Response Spectra of Workers and Drones to Queen Honeybee Mandibular Gland Components: The Evolution of a Social Signal. Naturwissenschaften, 85, 283-285. https://doi.org/10.1007/s001140050500

Callow, RK, Johnston, NC & Simpson, J 1959. 10-Hydroxy-Δ2-decenoic acid in the honeybee (Apis mellifera). Experientia, 15, 421-422. https://doi.org/10.1007/BF02157689

Currie, RW 1987. The Biology and Behaviour of Drones. Bee World, 68, 129-143. https://doi.org/10.1080/0005772X.1987.11098922

Free, JB & Williams, IH 1975. Factors determining the rearing and rejection of drones by the honeybee colony. Animal Behaviour, 23, 650-675. https://doi.org/10.1016/0003-3472(75)90143-8

Gary, NE 1962. Chemical Mating Attractants in the Queen Honey Bee. Science, 136, 773-774. https://doi.org/10.1126/ science.136.3518.773

Gries, M & Koeniger, N 1996. Straight forward to the queen: pursuing honeybee drones (Apis mellifera L.) adjust their body axis to the direction of the queen. Journal of Comparative Physiology A, 179, 539-544

Haydak, MH 1957. The Food of the Drone Larvae. Annals of the entomological society of America, 50, 73-75. https://doi.org/10.1093/aesa/ 50.1.73

Haydak, MH 1970. Honey Bee Nutrition. Annual Review of Entomology, 15, 143-156. https://doi.org/10.1146/annurev.en.15.010170.001043

Hepburn, H, Pirk, C & Duangphakdee, O 2014. Honeybee Nests, Berlin, Heidelberg, Springer.

Howell, DE & Usinger, RL 1933. Observations on the flight and length of life of drone bees. Annals of the entomological society of America, 26, 239-246

Johannsmeier, M 2001. Beekeeping in South Africa, Agricultural Research Council of South Africa, Plant Protection Research Institute.

Jones, JC, Myerscough, MR, Graham, S & Oldroyd, BP 2004. Honey Bee Nest Thermoregulation: Diversity Promotes Stability. Science, 305, 402. https://doi.org/10.1126/science.1096340

Koeniger, G 1986. Mating Sign and Multiple Mating in the Honeybee. Bee World, 67, 141-150. https://doi.org/10.1080/0005772X.1986.11098892

Koeniger, G, Koeniger, N & Fabritius, M 1979. Some Detailed Observations of Mating in the Honeybee. Bee World, 60, 53-57. https://doi.org/10.1080/0005772X.1979.11097736

Koeniger, N & Koeniger, G 2000. Reproductive isolation among species of the genus Apis. Apidologie, 31, 313-339. https://doi.org/10.1051/apido:2000125

Kraus, FB, Neumann, P, van Praagh, J & Moritz, RFA 2004. Sperm limitation and the evolution of extreme polyandry in honeybees (Apis mellifera L.). Behavioral Ecology and Sociobiology, 55, 494-501. https://doi.org/10.1007/s00265-003-0706-0

Lee, PC & Winston, ML 1987. Effects of reproductive timing and colony size on the survival, offspring colony size and drone production in the honey bee (Apis mellifera). Ecological Entomology, 12, 187-195. https://doi.org/10.1111/j.1365-2311.1987.tb00997.x

Lensky, Y, Cassier, P, Notkin, M, Delorme-Joulie, C & Levinsohn, M 1985. Pheromonal activity and fine structure of the mandibular glands of honeybee drones (Apis mellifera L.) (Insecta, Hymenoptera, Apidae). Journal of Insect Physiology, 31, 265-276. https://doi.org/10.1016/0022-1910(85)90002-2

Lindauer, M 1952. Ein beitrag zur frage der arbeitsteilung im bienenstaat. Zeitschrift für vergleichende Physiologie, 34, 299-345. https://link.springer.com/content/pdf/10.1007/BF00298048.pdf

Mattila, HR, Burke, KM & Seeley, TD 2008. Genetic diversity within honeybee colonies increases signal production by waggle-dancing foragers. Proceedings of the Royal Society B: Biological Sciences, 275, 809-816. https://doi.org/10.1098/rspb.2007.1620

Mattila, HR, Rios, D, Walker-Sperling, VE, Roeselers, G & Newton, ILG 2012. Characterization of the Active Microbiotas Associated with Honey Bees Reveals Healthier and Broader Communities when Colonies are Genetically Diverse. PLoS ONE, 7, e32962. https://doi.org/10.1371/journal.pone.0032962

Mattila, HR & Seeley, TD 2007. Genetic Diversity in Honey Bee Colonies Enhances Productivity and Fitness. Science, 317, 362. https://doi.org/10.1126/science.1143046

McNally, L, C. & Schneider, S, S. 1994. Drone production and drone comb utilization in colonies of the African honey bee, Apis mellifera scutellata Lepeletier, in Africa. Apidologie, 25, 547-556. https://doi.org/10.1051/apido:19940605

Menzel, JG, Wunderer, H & Stavenga, DG 1991. Functional morphology of the divided compound eye of the honeybee drone (Apis mellifera). Tissue and Cell, 23, 525-535. https://doi.org/10.1016/0040-8166(91)90010-Q

Mindt, B 1962. Untersuchungen ueber das Leben der Drohnen, insbesondere Ernaehrung und Geschlechtreife. Z. Bienenforsch., 6, 9-33

Moritz, R, Beye, M & Hepburn, H 1998. Estimating the contribution of laying workers to population fitness in African honeybees (Apis mellifera) with molecular markers. Insectes Sociaux, 45, 277-287. https://doi.org/10.1007/s000400050088

Moritz, RFA, Kraus, FB, Kryger, P & Crewe, RM 2007. The size of wild honeybee populations (Apis mellifera) and its implications for the conservation of honeybees. Journal of Insect Conservation, 11, 391-397. https://doi.org/10.1007/s10841-006-9054-5

Neumann, P, Moritz, RFA & van Praagh, J 1999. Queen mating frequency in different types of honey bee mating apiaries. Journal of Apicultural Research, 38, 11-18. https://doi.org/10.1080/00218839.1999.11100990

Ohtani, T 1974. Behavior Repertoire of Adult Drone Honeybee within Observation Hives (With 9 Text-figures and 2 Tables). Journal of the Faculty of Science of Hakkaido University, 19, 706-721

Ohtani, T & Fukuda, H 1977. Factors Governing the Spatial Distribution of Adult Drone Honeybees in the Hive. Journal of Apicultural Research, 16, 14-26. https://doi.org/10.1080/00218839.1977.11099855

Parker, GA 1970. Sperm competition and its evolutionary consequences in the insects. Biological Reviews, 45, 525-567. https://doi.org/10.1111/j.1469-185X.1970.tb01176.x

Planta, Av 1888. Ueber den Futtersaft der Bienen. 12, 327-354. https://doi.org/doi:10.1515/bchm1.1888.12.4.327

Plettner, E, Otis, GW, Wimalaratne, PDC, Winston, ML, Slessor, KN, Pankiw, T & Punchihewa, PWK 1997. Species- and Caste-Determined Mandibular Gland Signals in Honeybees (Apis). Journal of Chemical Ecology, 23, 363-377. https://doi.org/10.1023/B:JOEC.0000006365.20996.a2

Reyes, M, Crauser, D, Prado, A & Le Conte, Y 2019. Flight activity of honey bee (Apis mellifera) drones. Apidologie, 50, 669-680. https://doi.org/10.1007/s13592-019-00677-w

Ruttner, F 1966. The Life and Flight Activity of Drones. Bee World, 47, 93-100. https://doi.org/10.1080/0005772X.1966.11097111

Schiemenz, P 1883. Über das Herkommen des Futtersaftes und die Speicheldrüsen der Biene nebst einem Anhange über das Riechorgan, Engelmann.

Seeley, TD 2002. The effect of drone comb on a honey bee colony's production of honey. Apidologie, 33, 75-86. https://doi.org/10.1051/apido:2001008

Seeley, TD & Tarpy, DR 2007. Queen promiscuity lowers disease within honeybee colonies. Proceedings of the Royal Society B: Biological Sciences, 274, 67-72. https://doi.org/10.1098/rspb.2006.3702

Snodgrass, RE 1910. The anatomy of the honey bee, Washington, United States Department of Agriculture, Bureau of Entomology.

Streinzer, M, Brockmann, A, Nagaraja, N & Spaethe, J 2013. Sex and Caste-Specific Variation in Compound Eye Morphology of Five Honeybee Species. PLoS ONE, 8, e57702. https://doi.org/10.1371/journal.pone.0057702

Tarpy, DR, Keller, JJ, Caren, JR & Delaney, DA 2012. Assessing the Mating 'Health' of Commercial Honey Bee Queens. Journal of Economic Entomology, 105, 20-25. https://doi.org/10.1603/ec11276

Tarpy, DR, vanEngelsdorp, D & Pettis, JS 2013. Genetic diversity affects colony survivorship in commercial honey bee colonies. Naturwissenschaften, 100, 723-728. https://doi.org/10.1007/s00114-013-1065-y

Utaipanon, P, Holmes, MJ & Oldroyd, BP 2019. Queenless colonies contribute to the male breeding population at honey bee drone congregation areas. Insectes Sociaux, 66, 593-599. https://doi.org/10.1007/s00040-019-00720-0

Vallet, AM & Coles, JA 1993. The perception of small objects by the drone honeybee. Journal of Comparative Physiology A, 172, 183-188. https://doi.org/10.1007/BF00189395

Visscher, PK 1996. Reproductive conflict in honey bees: a stalemate of worker egg-laying and policing. Behavioral Ecology and Sociobiology, 39, 237-244. http://www.doi.org/10.1007/s002650050286

Wanner, KW, Nichols, AS, Walden, KKO, Brockmann, A, Luetje, CW & Robertson, HM 2007. A honey bee odorant receptor for the queen substance 9-oxo-2-decenoic acid. Proceedings of the National Academy of Sciences, 104, 14383-14388. https://doi.org/10.1073/pnas.0705459104

Winston, ML 1987. The Biology of the Honey Bee, Cambridge, MA, Harvard University Press.

Woyciechowski, M, Kabat, L & Król, E 1994. The function of the mating sign in honey bees, Apis mellifera L.: new evidence. Animal Behaviour, 47, 733-735. https://doi.org/10.1006/anbe.1994.1101

Woyke, J 1964. Causes of Repeated Mating Flights by Queen Honeybees. Journal of Apicultural Research, 3, 17-23. https://doi.org/10.1080/00218839.1964.11100077

Woyke, J & Ruttner, F 1958. An Anatomical Study of the Mating Process in the Honeybee. Bee World, 39, 3-18. https://doi.org/10.1080/0005772X.1958.11095028


For
making a difference
As the Ford Wildlife Foundation we are proud to assist, support and celebrate those who protect South Africa's rich biodiversity. From enabling our partners to reach remote locations with our Ford Rangers to supplying them with protective face shields, we'll continue to help those who make a positive contribution to this beautiful country.
WILDLIFE FOUNDATION
ENDANGERED WILDLIFE TRUST
RANGER
#ForSouthAfrica
Ford

Did you know that honey bee sperm perform swimming relays?

By: Retha C.M. Kotze, Gerhard van der Horst, Anja Duminy, Janice Murray University of the Western Cape, Bellville, 7535

What do honey bee sperm look like?

Honey bee sperm, as with many other insect species, has a thin head and a very long tail and is about four times longer than any mammalian sperm.

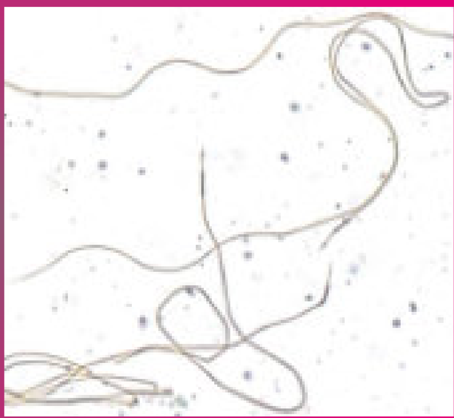

Figure 1: Cape honey bee drone sperm stained with silver nitrate

Relay swimming

A queen receives and stores millions of sperm from as many as 40 drones during her mating flights. Inside the spermatheca (female receptacle for holding sperm), groups of sperm swim in a circular or helical fashion, as observed in artificially inseminated and naturally mated queens (Tofilski et al., 2018). Reasons suggested for this swimming pattern includes the size of the spermatheca, to allow for storage of sperm with long tails (Borsuk et al., 2011), to prevent entanglement during storage, and to serve as a releasing mechanism of sperm to participate in fertilization (Al-Lawati et al., 2009). Indeed, it has been suggested that groups of circular swimming sperm, swim close to the spermathecal wall to have an opportunity to fertilize eggs (Tofilski et al., 2018).

Research investigating particularly honey bee sperm movements has mainly been conducted on Apis subspecies outside Africa, and very little information is available on the southern African honey bee subspecies' sperm behaviour and characteristics. Therefore, our research group recently started to investigate honey bee drone sperm of the Cape honey bee and made several observations about drone sperm swimming patterns. One of the most important observations made is that groups of circular swimming sperm, actually perform relay swimming, which refers to groups of sperm (up to 15) swimming together as a team in a typical helical fashion (Figure 2). Another interesting behaviour noted was that while sperm are swimming in a group, they can exit, and or re-enter the group; even "outsider" sperm can also join a group of sperm. The latter are usually individual sperm that are already swimming in a circular fashion. Furthermore, when a sperm leaves the group, it does so in a slingshot manner, which relates to the releasing mechanism suggested for fertilization. Such individual sperm usually then start to swim in a snake-like pattern away from the group.

Figure 2: Groups of relay swimming drone sperm (Adapted from Murray, J. 2019)

Furthermore, relay swimming groups of sperm, swim faster (have greater velocity) (Wegener et al., 2012), a functional characteristic that, along with the other proposed roles of circular swimming sperm, can favour the fertilization of eggs by the sperm. Moreover, both the presence of numerous groups of relay swimming sperm and increased motility may be indicators of sperm quality.

Swimming speed of honey bee sperm

After copulation, sperm are temporarily stored in the queen's lateral oviducts, from where they migrate to reach the spermatheca for long term storage (Brutscher et al., 2019). Owing to the difference in sperm numbers per individual drone in the lateral oviducts (about 10%) and those reaching the spermatheca (about 3-5%) (Brutscher et al., 2019), creates the possibility of intra-oviductal sperm competition as suggested by Woyciechowski and Król, (1996. Eventually a sperm needs to reach an egg for fertilization via the spermathecal duct (leading back to the oviducts), and as many eggs need to be fertilized daily, sperm of poor quality, such as sperm that are not able to survive storage or not motile enough to reach the eggs, may have adverse effects on fertilization success and reproductive capability of the colony, particularly if making up a large percentage of the stored sperm.

In promiscuous animals, it is well known that there is a great deal of sperm competition, and in honey bees between-male competition previously observed, does indicate that this may be a possibility (Couvillion et al., 2010). For example, drones of smaller size seem to have several disadvantages compared to normal size or larger drones when it comes to mating. Smaller drones produce lower sperm volumes, achieve fewer matings and subsequently contribute less to the paternity of offspring (Couvillion et al., 2010; Brutscher et al., 2019). Furthermore, drones flying closer to the drone congregation area, have higher sperm numbers (Koeniger et al., 2005). However, sperm numbers do seem to vary greatly amongst drones, even within the same colony (Couvillion et al., 2010). As a result of sperm competition, that occurs in many species, traits related to sperm structure (e.g. length of sperm) and function (e.g. progressive motility, and swimming speed) are also important for fertilization success. In case of the honey bee, characteristics of individual drone sperm and their role in sperm competition is poorly understood, and requires further investigation.

Mating with multiple drones is to the advantage of a colony, to maintain genetic diversity, and perhaps it makes sense that allowing only a small amount of individual drone sperm in the spermatheca of each drone is a measure to ensure this genetic diversity. However, important questions arise. For example, which sperm enter the spermatheca and on what basis (referring to its characteristics), and do only sperm that swim faster enter the spermatheca in time before excess sperm is expelled? We are thus, amongst other sperm characteristics, interested in determining drone sperm motility paramaters, such as swimming speed as a possible trait related to sperm competition.

Sperm swimming speed can be measured manually, using hand-tracking of sperm from video recordings made under phase-contrast microscopy. This is a time-consuming method that allows for tracking individual sperm, but is extremely difficult or often impossible when trying to follow larger representative populations of sperm. The reason for this is the thin needle-like structure of honey bee sperm, which makes it difficult to distinguish between its head and tail. It is, therefore, one of our aims to use computer aided semen analysis (CASA) that has been used routinely to assess sperm swimming speed in other animal species. The benefit of such a system is that it allows for more rapid and accurate assessment of sperm quality assessed through swimming speed.

In order to detect and track honey bee sperm heads using CASA we make use of a stain that makes the sperm head visible using a fluorescence microscope (Figure 3). By using these techniques and technology, we managed to analyse honey bee sperm swimming speed quickly and accurately. From our findings, it was confirmed that relay swimming honey bee sperm were indeed swimming faster!

Figure 3: Cape honey bee drone sperm stained with SYBR14 (Adapted from Murray, J. 2019)

Honey bee drone sperm quality

Drones must produce sperm of high quality, thus sperm that can migrate through the reproductive tract of the queen after mating, that are able to survive, and that maintain the ability to fertilize eggs during long term storage in the queens' spermatheca. Furthermore, drone semen has remarkable effects on queen quality and affects the whole colony (Brutscher et al., 2019; Jasper et al., 2020).

Colony losses occur as a result of various factors, and are often attributed to queen quality, which in turn are dependent on drone semen quality. In addition, sperm characteristics, may also influence their ability to migrate through the female reproductive tract, survive during storage, and fertilize eggs. If drones in the proximity of a drone congregation area have semen (including sperm) of good quality, one can hypothesise that the queen mated with such a drone, will head a strong colony. Furthermore, in order to replace colony losses, successful reproduction is key and the use of artificial insemination to optimize selection of certain genetic lines, has become important and assessment of drone semen samples prior to insemination can play a crucial role to ensure the use of sperm of high quality.

Sperm numbers, sperm volume, and sperm viability have long been acknowledged as markers of sperm quality. However, the ability of sperm to be motile and the types of movement in relation to its fertilizing ability, have received less attention. Given the vital role drone sperm plays in the success of a colony, our research group regards it of importance to investigate and identify all sperm traits that will favour queen quality and colony performance. Equally important, is to determine the effect of several environmental factors on the reproductive biology of drones, particularly their sperm structure and function.

References

Al-Lawati, H., Kamp, G. and Bienefeld, K. 2009. Characteristics of the spermathecal contents of old and young honeybee queens. Journal of insect physiology, 55:117-122.

Borsuk, G., Olszewski, K., Strachecka, A., Paleolog, J. and Gagos, M. 2011. Microscopic image of honeybee drone spermatozoa in three diluents. Journal of apicultural science, 55:5-13.

Brutscher, L.M., Baer, B. and Niño, E.L. 2019. Putative drone copulation factors regulating honey bee (Apis mellifera) queen reproduction and health: A review. Insects, 10:8.

Couvillion, M.J., Hughes, W.O.H., Perez-Sato, J.A., Martin, S.J., Roy, G.G.F. and Ratnieks, F.L.W. 2010. Sexual selection in honey bees: colony variation and the importance of size in male mating success. Behavioral ecology, 21:520-525.

Jasper, W.C., Brutscher, L.M., Grozinger, C.M. and Niño, E.L. 2020. Injection of seminal fluid into the hemocoel of honey bee queens (Apis mellifera) can stimulate post-mating changes. Scientific reports, 10:1-18.

Koeniger, G., Koeniger, N., Tingek, S. and Phiancharoen, M. 2005. Variance in spermatozoa number among Apis dorsata drones and among Apis mellifera drones. Apidologie, 36:279-284.

Murray, J. 2019. The developmental effect of maturity and unusual apiary rearing conditions on Cape honey bee drone spermatozoa. Honours thesis. University of the Western Cape, Bellville.

Tofilski, A., Chuda-Mickiewicz, B., & Czekonska, K., 2018. Circular movement of honey bee spermatozoa inside spermatheca. Invertebrate reproduction & development, 62:1-4

Wegener, J., May, T., Knollman, U., Kamp, G., Muller, K., & Bienefeld, K. 2012. In vivo validation of in vitro quality tests for cryopreserved honey bee semen. Cryobiology, 65:126-131.

Woyciechowski, M. and Król, E. 1996. On intra-oviductal sperm competition in the Honeybee (Apis mellifera). Folia biologica (Kraków), 44:51-53.

Pollination Specialists

Company Registration 2018/225546/07

POLLINATION

Advise - Training - Inspections

Philip du Toit
083 401 1116

Adriaan du Toit
083 306 1446

Beekeeping – The Seeing is Believing International Tour

The 47th Apimondia International Beekeeping Congress & Api-Expo
Ufa, Russia. 5-10 September 2022

Detailed Guided International Beekeeping Experience

UFA, Russia will be hosting the 47th Apimondia International Apicultural Congress in 2022.

APIMONDIA is the International Federation of Beekeepers' Associations. Its major objective is to facilitate the exchange of information and discussions by organizing Congresses and Symposia where beekeepers, scientists, honey traders, agents for development, technicians and legislators meet to listen, discuss and learn from one another. Apimondia meetings are fabulous events that offer great opportunities to learn about all the aspects of the beekeeping world. During these meetings, from morning until late evening, participants explore various exhibits and learn about cutting edge research from all parts of the world. It is expected that this edition of the Apimondia Congress will be visited by 12,000 beekeepers from around the world.

As delegate you will have direct seating in the Special Meeting – Beekeeping for Rural Development and Poverty Relief to participate and contribute and also join the Round Table African Beekeeping discussion.

Programme Content:

- ✓ Opening ceremony
- ✓ Scientific programme
- ✓ Mini Research Symposia
- ✓ Round table Discussions
- ✓ Api-Expo with more than 500 beekeeping exhibitors open all week
- ✓ Russia Local Beekeeping excursions and sightseeing
- ✓ Closing ceremony
- ✓ Optional site seeing in Russia and or Europe
- ✓ Optional visit African Beekeeping in Kenya or Ethiopia

47th APIMONDIA
International Apicultural Congress
September 5-10, 2022
UFA - RUSSIA

Online electronic registration now open: Full Congress Entry Fee (South Africa member country)
1st Early bird deadline: May 28th, 2022 at 325.-Euro and 2nd Early bird deadline: August 19th, 2022 at 375.-Euro and from August 20th, 2022 full registration fees of 425.-Euro. https://apimondia2021.com/

Macadamia Roadshow

Forage to sustain pollinators and bee populations

By: Dr. Adriaan du Toit & Inge Lotter

Context

In many regions of South Africa, there are areas where intensive agricultural production is practised that require the pollination services provided by honey bee colonies. Associated with these monocultural areas of plant production such as macadamia orchards, it is often the case that good forage to sustain the bee colonies is scarce to absent during the dry season. This drives the need to move colonies in order to ensure that they survive throughout the year.

As macadamia orchards expand to meet market demand, both nationally and globally, they generate progressively an increased demand for pollination services provided by honey bees and hence an increase in the number of managed colonies that can satisfy this demand. If 51 000 Ha of macadamia trees are planted that will come into production in 2 – 3 years' time, this will increase the demand for pollination services exponentially. Within the next 10 years, it has been estimated that double the current number of bee colonies will be required to successfully pollinate crops in SA. This demand is unsustainable with the current floral resources available to the bees and the constraints of space for the placement of apiaries. The most critical of these factors is the availability of floral resources throughout the year. It is therefore critical to obtain the support of all stakeholders to secure adequate bee forage to ensure that there are sufficient healthy colonies to satisfy current and future pollination demands.

Although good sources of forage for colonies is available at certain times of the year such as from Eucalyptus trees, citrus orchards, subtropical fruit trees, and certain indigenous plants such as aloes, the problem is one of providing sources of forage outside of the main season for these sources of nectar and pollen.

There is an urgent need to initiate responsible planting of non-invasive bee forage plants that will enable bee populations to persist throughout the year. Without this measure, there will not be enough bees to effectively pollinate the crop.

Macadamia orchards as bee forage

The question for beekeepers is the extent to which macadamia orchards can provide forage that will sustain the colonies while they are providing pollinations services:

- the nectar produced by the flowers is primarily an energy source, but in addition to sugars contains various minor ingredients that have nutritional significance,
- the pollen provides bees with the protein, lipids, vitamins, and minerals that are essential for larval rearing,
- the quality of macadamia pollen and nectar may vary.

According to Johannsmeier's Beeplants of South Africa, Macadamia has pollen that ranges from 16% to 22% crude protein. Bees need at least 20% crude protein that includes 10 amino acids in order to have an adequate diet. Macadamias have a deficiency in one of the amino acids and some lipids are not present. It may be necessary for beekeepers to provide their colonies with supplementary feeding in order to make up for the deficiencies of the pollen that they are collecting.

Macadamia orchards may look like a haven for bees, with a pollination period of beween 3 to 4 months, but the colonies may need additional food, and they need to be sustained once the flowering season is over.

How to prevent colonies from absconding once the flowering season is over

The African honey bee subspecies are known to migrate when foraging conditions deteriorate in the area where they are located. This means that when forage becomes limited, the colony is likely to move off. Although there are a variety of reasons why colonies abscond, lack of forage is the one that is most problematic for both beekeepers and farmers that own colonies of bees.

What can be done to reduce the degree of absconding?

Planting of bee forage plants

Using areas such as rocky outcrops and road verges allows for the planting of bee forage. Ideally plants in all their natural forms: pasture, shrubs and trees should be planted to ensure good varied bee nutrition. Plant small crops close or in between rows, and then plant bigger and bigger plants towards the edge of orchards. Some growers have bought land on which to keep their bees out of season and plant forage there.

Bee forage calendar

The use of a bee forage calendar can be useful in helping you to manage the health of your colonies. These calendars list the floral resources that are available throughout the year in your specific area and can be downloaded from the internet. You may have to move your colonies to sunflowers, etc., in order to provide pollination services. Pollinators are required during winter and early spring, the colonies need food and preparation before providing their pollination services. Once pollination has been completed, the colonies need to be moved to locations where they can be sustained until required again. Eucalyptus can be used in January and February to sustain colonies, but February is often a month in which there is a dearth of floral resources.

What can be planted on Macadamia farms to maintain swarms in the offseason?

Planning the vegetation on the macadamia farm can be helpful in ensuring that there is forage for the bees that supplements macadamia nectar when it is available and which provides food when the flowers are no longer present. Trees such as litchi or citrus can be planted on the farm to supplement the bees' nectar requirement in the macadamia flowering season and offset the deficiencies of macadamia nectar. The following plants can be used to provide forage for the bees during the year:

African blue Basil – Sterile and prolific year round flowering

This plant needs to be managed so that it does not compete with macadamia flowers when they are being pollinated. The plants can be cut to below the flowering line in August os that their blooms are not present when the macadamia is being pollinated.

Lavender

Planted on the edge and in between rows. Cut them during the macadamia flowering season as above.

Aloes

Different Aloe species should be planted en masse or as hedge rows. Provides abundant pollen to build up colonies.

- *Aloe arborescens* will start flowering within two years and
- *Aloe marlothii* can take up to 4 years to start blooming.

Trees

- Apiesdoring (*Senegalia galpinii*)– flowers are produced during September - October and provide good forage for bees.
- Eucalyptus– only 8 of the eucalypts are invasive that leaves 410 species that are not listed that can be planted. The plants will take 4 – 5 years to come into full flower. You need a permit to plant the non-invasive species and there is no reason for a permit to be denied. There is a popular perception that eucalypts have to be eradicated, but this not true. Eucalyptus species are not always large trees but can still be significant bee forage providers and still remain some of the best sources of bee forage available in South Africa.

Herbs

- White clover – Year-round, excellent as fodder
- White sweet clover – Summer flowering
- Lucerne – easy to maintain, plant only every 4 years
- Buckwheat – one of the highest pollen nectar contents, available during the critical Summertime
- Tagasaste (Tree Lucerne) – sandy soil, flowering August to October

Using the variety of plants listed above can ensure that macadamia orchards are able to sustain honey bee colonies throughout the year and ensure that the bees are available when the orchards require pollination.

Reference Book

Martin Johannsmeier (2018) Beeplants of South Africa. ISBN 978-1-928224-17-4, Published by SANBI.

Honeybees improve macadamia crop yields

By: Dr Hannelie Human

The effect of pollination is measured in crop yield, i.e. what you can harvest and the quality of the nuts. Dr Hannelie Human shares the outcomes of her study that measured the effect of pollination on macadamia yields.

Details of pollination?

Pollination involves the transfer of pollen grains to the stigma of a plant so that the seeds are fertilized and begin to grow.

Self-pollination is when pollen from the same flower or flowers on the same plant are transferred to the stigma.

Cross-pollination is the transfer of pollen from flowers on different plants to the flowers of the pollinated plant. Transfer of pollen between plants from between cultivars maybe even more effective.

In macadamias, multiple pollen grains may be transferred to a single stigma, up to 150 grains.

How important is pollination for Macadamias?

Cross-pollination between cultivars has shown the largest increase in yield, while self-pollination is less effective.

Macadamia farmers need to improve the chances for cross-pollination and can employ honey bees to do this task. Honey bees are recognized globally as one of the most effective cross pollinators, outranking all other insects and other species of bees.

The effectiveness of honey bees as pollinators relates to the fact that each colony has from 40 000 to 60 000 worker bees, a large number of whom can visit flowers and affect pollination. The pollinating bees also move from one flower to the next on different plants and hence enhance cross-pollination. Colonies of honey bees placed in orchards will provide this pollination service.

The use of pesticides in orchards, while the honey bee colonies are being used for pollination, needs to be strictly regulated by the farmers to ensure that colonies are not killed by the pesticides. Thus coordination between farmers and beekeepers is essential.

The Aim of the Study

- To investigate the impact of honey bee pollination on nut production in macadamia cultivars Beaumont (695), 816, 814 and A4.
- To determine whether macadamia nectar is attractive to bees?
- To determine whether sufficient nectar is produced to sustain colonies in the orchards for the duration of the flowering period?

Flowers need to be attractive and provide enough fuel for foraging flight

Honeybees require nectar that has a sugar content of between 15 – 65%. Nectar with a sugar content below 20% is not attractive and cannot sustain the bees, 20% - 35% is adequate, while 35% – 65% is optimal.

Did the flowers produce enough nectar?

The flowers were studied using exclusion bags placed over the flowers to exclude honey bees and other flower visitors from removing nectar. Nectar production as measured after 24 hours of excluding flower visitors.

The study found that all flowers produced more that 12 µl of nectar. The honey bees that were leaving the flowers were found to have a nectar load of 18 µl which indicates that the flowers were producing sufficient nectar to be able to sustain the bees.

Was the nectar concentrated enough?

The study found that the sugar concentration of the nectar was above 20%. In addition, the honey bees were observed to evaporate water from the nectar that they had collected before they left the flowers. In this way they were transporting a more concentrated nectar solution to the colony than the one that they had collected. The bees were transporting a more energy concentrated form of nectar to the hive than they were collecting from the flowers.

Results of impact on yield

The nut set % was found to be significantly higher when honey bees were present in the orchard. Orchards without honey bees resulted in 33% to 67% lower nut set in all 4 cultivars studied.

To measure the yield, crop size, nut size and kernel weight were recorded. Nut size was found to increase by at least 2 mm in diameter. There was a significant increase in kernel weight.

Cultivar 814 was found to benefit the most from honey bee pollination with the yield showing and increase of 72% more nuts, an increase of 6mm in nut size and 33.6% increase in wieght. All 4 cultivars benefitted from honey bee driven pollination with A4 showing the lowest but still significant increase at 67% more nuts and 8% increase in nut weight.

Conclusion

The preliminary results given here indicate that macadamia growers will derive a significant benefit from having bee hives in their orchards to effect pollination of the flowers. The details of the way in which honey bee colonies can be used optimally in the orchards will be explored in future large scale studies. The details that need to be established are, how many colonies are needed per hectare, where they should be placed, and the strength of the colonies terms of the average number of workers that they contain that are placed in the orchards. Establishing these details will ensure that the growers get a reliable pollination service for their orchards.

From the perspective of the beekeepers, it is important the growers recognise the logistical difficulties of moving large numbers of colonies of honey bees safely to the orchards with the least stress being placed on the colonies. Most critical of all, is to ensure that the use of pesticides is strictly controlled so that the risk of poisoning colonies is minimal. There is not an overabundance of honey bee colonies that can be used for pollination, so those that are available need to be carefully protected.

Effective pollination of macadamia by honey bees will result from well developed co-operation between growers and beekeepers, with a mutual understanding of their respective requirements.

Maximizing Macadamia Pollination

By: Michel Lenferna

Pollination Aims and Objectives

In order to maximize the pollination of the crop, there is a need to provide the optimum number of healthy, strong and active honey bees, at the beginning of the bloom, with the hives placed throughout the orchards in a pattern ensuring the uniform distribution of pollinating bees.

The growers need to have the assurance of a reliable source of bees at a reasonable cost at the time of flowering.

The Current Scenario

Insect pollination is critical for nut set, since macadamia flowers are not wind-pollinated. There are many different bees and other insects that do pollination, but to ensure that pollination is achieved effectively, honey bees are required. and this can only be achieved through the use of honey bees as a pollinator. Pollen is collected by and adheres to honey bees easily and they transfer it between flowers effectively. Their large population numbers ensure that pollination is effective a the scale of the whole orchard.

Macadamia farmers are subject to fluctuations in the supply/demand for bees and this uncertain situation is likely to worsen in the future since the entry of new young beekeepers into the business is low largely because of low-profit margins. Considering the growth in the areas planted to all crops annually, it is clear that thousands of hectares are added every year. The increase in the number of bee colonies available for pollination has not grown to the same extent. In fact, many of the current beekeepers are stopping their operations as a result of vandalism, theft and the poor price of honey.

Stocking Density

The number of hives required to provide a good pollination service has been determined to be between 5 to 8 hives per ha, although some experts recommend 12 per ha. It is difficult to determine what a realistic number of hives ought to be. The supply of colonies makes the higher numbers difficult to achieve and the higher stocking densities also result in colonies absconding from their hives as a result of competition for limited floral resources.

Currently, there is no definitive research to provide guidance on stocking density. Each site is different in respect of age, cultivar, size of orchard, climate, aspect, soil fertility, management (pruning is critical, bees do not like to work in the dark), distribution of hives through the orchard (preferably putting them slightly outside the orchard, as high up as possible – they will be safer and easier for your management), competing nectar/pollen sources (bees staying long-term need food diversity), nut set required and the strength of the colonies.

Colony Strength

The properties of colonies that are going to be used for pollination are:

- The colony must be Queenright which means that a laying queen is present.
- The number of bees in the colony - as a rough guide, there should be at least 6 frames covered with bees in a hive.
- The amount of brood present in the colony since the presence of larvae stimulates feeding and hence encourages pollination. Hives should be inspected to ensure that there are 3 – 4 frames of brood present.
- The brood in the frames should range in age from eggs to capped cells, to ensure that the colony is able to sustain its worker force for pollination.
- Honey stores should be present so that the colony stays in the right stage of production when it is brought to an orchard for pollination.
- Swarming (colonies should be inspected to reduce the possibility of swarming)

Increase production potential of orchards by having:

- Best land affordable
- Best land preparation possible (ridging, drainage, cover crop, wind breaks, compost, mulch, roads)
- Provided irrigation (pipelines, balancing dams, pump houses)
- Best levels of management (pruning, disease/pest control, security, equipment, training, staff, weather station).

Having attended to all of the above factors, the question then arises - **How does it make sense to have minimum pollination???**

Clearly, if you do not pay attention to pollination, then all of the preparation of the orchards will be in vain. There will be a billion flowers per season that need pollination and the flowers take as many as 15 bee visits to achieve pollination over a period of 12 days. to achieve this, a strong force of worker honey bees is required. To bring in a hive to do this, you need only an extra 6 nuts per tree to make it worth your while.

Start with a few hives in a year and add more every year to determine what your optimum number of hives will be. Stocking the orchard with the correct number of hives is cost effective. Considering that macadamia capital costs are R500 000 per ha, skimping on pollination is short-sighted.

Sources of Hives

Free

Wild colonies of honey bees may be present in the vicinity of the orchards, but their numbers and strength vary, their travelling distance to the orchard will vary, there may be alternative food sources that they prefer. There are no costs associated with this pollination service but there is also no way of gauging their effectiveness.

Hire colonies or establish your own.

Grower Owned

The provision of your own colonies requires a high start-up cost, and specialized skill/knowledge to maintain the colonies. You will have control over the provision of the bees and will not have to pay a fee for the hiring of colonies. There may also be some alternative income from honey. The maintenance of the colonies requires that in addition to managing the orchards, there is a requirement to manage the bee colonies. Whether the grower has the time (and the expertise) to invest in two separate operations will determine whether this option is feasible.

Commercial Beekeeper

Hiring colonies from a commercial beekeeper eliminates the management of colonies, and the grower can specify the requirements while incurring an annual cost for the provision of this service. The beekeeper who is employed needs to have extra expertise and management skills to ensure that they can provide the pollination services when required. In most cases, it will make economic sense for a commercial farmer to rent hives from a commercial beekeeper.

Hiring Fees for honey bee colonies

iThe beekeepers who provide colonies for pollination services are running a business at a profit and they incur significant costs to provide the bees. There are also a number of risk factors for them to contend with such as diseases, theft, vandalism and loss of colonies through careless use of insecticides. All of these factors dictate the cost of hiring the colonies. Here are some of the factors:

- Supplying and housing colonies of honey bees, with colonies of bees being more and more in demand as the size of plantations increase.
- The value of hives has to be depreciated over 10 years as they suffer wear and tare due to pollination,
- The movement of the colonies into orchards and out again leads to the loss of colonies as a result of disturbing them during the move and of damage to hives.
- The preparation of the colonies for pollination services entails feeding and stimulation costs, depending on the availability of alternative food sources prior to their use.

- The hives need to be managed in a sequence - Pre-pollination – feeding and brood management; preparing for the move in; During pollination – brood and space management; preparing for the move out; Post pollination - Since there is limited forage available to support colonies of bees there are few places where colonies can be safely kept.

- Cost of providing pollination services Macadamia trees are not big producers of nectar, so there is no honey dividend from providing the pollination service

- The cost of transporting the colonies into the orchards and then relocating is significant.

- The cost of labour that is used to manage the colonies and to transport them has to be accounted for.

- Vandalism / Theft - the bees are a soft target in unprotected areas. Professional beekeepers suffer significant losses per year due to this. The decision to reclassify bees as livestock may help with pursuing those responsible for theft and vandalism.

- The management of honey bees in order to provide pollination services requires specialist knowledge and a high level of management skills in order to operate successfully.

If you choose to use your own

Beekeeping is a highly specialized form of stockman-ship and pollination is a specialized form of beekeeping. In addition, beekeeping is a hard, physical, hot, often dirty, often painful occupation, that involves working antisocial hours since they are moved at night and sometimes over long distances that require a full night's work.

- One can purchase bee hives from a number of different sources. Some are better than others. You can get them in a kit form and assemble them yourself or purchase a complete assembled hive.

- The bees to populate the hive have to be provided by catching swarms, breeding your own colonies or buying colonies from an existing beekeeper's stock.

- Out of season apiary sites need to be secured. The beehives cannot stay in the orchards but must be moved to secure sites with forage and water.

To do pollination takes Time, Money and Effort.

Whoever does it will have to be paid, either the beekeeper or yourself

Conclusion

How do the Macadamia farmers ensure the pollination of the crop? They need to have a reliable source of honey bee colonies that they can hire at a reasonable cost. To do this they should enter into a signed agreement with their beekeeper well ahead of the next flowering season. There should be a good working relationship between the farmer and beekeeper to ensure that a good harvest is achieved.

Macadamia Pest Management

Background

New developments in pest management are taking place against the backdrop of the threat to insect populations worldwide as a result of the use of pesticides in agricultural production. As one of the largest importers of agricultural products, the EU can dictate the standards that will apply to the products imported. The Green Deal Programme to get Europe to Carbon Zero at 2050 also means that they can set standards that achieve this goal. They would like to limit the rise in global average temperature to 1.5 degrees. In order to achieve this, a target to stop manufacturing internal combustion engines has been set for 2030 for most manufacturers. Since SA is an exporter of vehicles, it will have to change here too.

For agriculture, there is a fear of pesticides and it is proposed that the number of registered pesticides be reduced by half by 2030. Fifty per cent of the Industry should be converted to organic production – which will be very difficult for Macadamias. The EU is looking at similar restrictions on the use of fertilizers and all products imported to Europe that make use of fossil fuels in production will be reviewed.

Eskom has indicated that most of our energy is produced from fossil fuels, with the proposal that there is a switch over to renewable sources of energy by 2030. If these changes are not effected, there is the expectation that significant levies will be imposed on products reliant on fossil fuel energy in their production.

Which pesticides will be targeted?

Organophosphates – The use of this class of insecticides is already banned and they are not used in South Africa.

Pest control products with the following characteristics are likely to be removed: broad-spectrum products with long residual actions; any product that has an effect on bees will be an issue, ie. products used to control stinkbugs; any product affecting endocrine glands in humans and animals.

Since 2016 the European Union has banned the use of Neonicotinoid insecticides such as Clothiandin, Impidacloprid and Thiamethoxam which have all been shown to have deleterious effects on honey bees.

Bayer international has not applied for further production/distribution of Thiamethoxam. This is an indication that it will be phased out by other manufacturers too. The problem with the neonicotinoids is that there will not be any residue in the nuts themselves, just the flowers will have residues.

The current pesticide use in Macadamias (list of pesticides)

In South Africa the list of products that may be used includes 58 items in total: 37 insecticides; 7 fungicides; and 14 herbicides, growth regulators etc. Compared with the list from the EU and CropLife International, it is clear that a ban on 37 items on the list is being considered. Only 16 of the items are not being considered for a ban, of which a third are conventional pesticides that are not currently in use and are unlikely to be used in the future.

Are conventional chemical pesticides all bad and organic products all good?

The answer to this question is a resounding No. Since 1960 global food production has nearly tripled as a result of pesticide usage. Hence, without crop protection, an estimated 50 – 80% of the world's food would be lost and there would be no food security for the human population. The use of crop protection chemicals enables farmers to produce safe, nutritious food at relatively affordable prices. In addition, these chemicals have controlled vectors of human diseases, i.e. the use of DDT to control the vectors of the malaria parasite.

Organic products are not necessarily free of risks to human health, the mycotoxins produced in stored organic grain are an enormously serious problem that far outweighs any possible risks associated with pesticide usage since they are responsible for initiating cancers in those who feed on this grain.

Are conventional chemical pesticides all bad and organic products all good?

The Green Deal Programme of the European Union is here to stay and will be phased in in steps, the first phase has a deadline of 2030 but some pesticides will be removed before then. It takes a long time to register a pesticide up to 7 years – this period of time is not acceptable for us to adapt and meet these targets. We have to speed up the process to be able to compete in the international market. We have only 9 years left!

New products will be very expensive. Pyrethroids are very old, patents expired therefore cheap. New products cost from EUR 600 000 to 1 million to be introduced into the market. Hence, a new stinkbug product could be priced at R5000 per kg.

Using the stinkbug as an example, it is easy to treat with a shotgun method, but this is not ideal as it uses a lot of product. A more focused approach should be applied to be cost-effective.

SAMAC is currently working on a handbook for diseases, the research that informs the treatment of these diseases will be combined into one book that farmers can use as a reference. Without the book, farmers are at the mercy of chemical reps, and the idea is to empower farmers to make the correct decisions about the use of products, and to use them responsibly and sustainably.

Software packages have been introduced that assist with the application of products and are very sophisticated. The software has the potential to network programmes with each other. The software requires accurate data about insects to be collected and hence better-integrated management can be introduced.

SAMAC is funding 3 projects:

- The most critical project deals with pruning and the effect of pruning for pest management. Tall trees cannot be managed properly. Lower volumes of pesticides will be required for trees that are appropriately pruned.
- The physics of spraying, how to deliver optimal spraying and wetting of trees.
- The third project will study the Macadamia Parasitoid that has been imported into South Africa. Its effectiveness is currently being evaluated, and it is due to be released soon.

The key pest of Macadamias is the stink bug, but safe options to manage this pest are not available at the moment.

Future developments

Gene technology is currently being explored to manage stinkbugs (Oxitech, UK). This technology would produce sterile females that would be released in orchards. The viability of this technique has still to be determined.

The integration between micro-electronics and farming – development of an 'enose' for stink bug monitoring, and 'enut' for post-harvest monitoring and tracking of stolen nuts. (Carl & Emily Fuchs Institute for Micro-electronics – University of Pretoria)

The Chemical ecology of tortricid moths and stink bugs is being explored. Products that act as repellents of stink bugs are being explored. In addition, both an oviposition stimulant and a repellent for tortricid moths are being tested.

Understanding the problem of the stink bug

Although the stink bugs occur in low numbers the damage that they cause is extreme. The presence of the bugs cannot be monitored effectively at the moment and the sprays that are used are not approved for use on stink bugs. There has been some progress made with pheromone products to allow for the monitoring of the populations. Most products registered currently will not be acceptable to EU.

It was standard practice to clear orchards before flowering, but spraying at this time will have no effect on stink bugs later. Also, over 99% of flowers will fall and not flower under any condition. Hence, the little stink bug infestation before flowering will have no or very little effect later. The best option is to protect the nuts which are hanging on the tree.

Nut borer complex – understanding the problem

Only one developmental stage of this insect can be controlled, egg / young larvae stage. it should be sprayed on the first week in December. Spraying before this period or after it does not produce good results.

The borers prefer the bottom inside of the tree, the pesticide needs to be delivered deep inside the tree. This is why pruning is important.

Many environmentally friendly products are available for spraying:

- Chemical pesticides
- Pheromones – monitoring, attract and & mating disruption
- Biological pesticides – fungi, bacteria nematodes & viruses
- Natural enemies

Thrips – what do we know?

The damage caused by thrips is largely cosmetic – thus it is a minor problem with Macadamias, and has no effect on the quality of the nuts. They may result in tiny leaf syndrome that could have an effect on yield. Research is being undertaken to determine what level of infestation it is safe to allow. The thrips could be passively transmitting diseases, i.e. dry flower disease, chlorosis. Spraying for this insect is not recommended and certainly not when the plants are flowering.

Predatory mites have a great effect on thrips, but when a spray is applied for stinkbugs the mites are killed, so therein lies the point that the control of Stinkbug is the biggest problem.

Macadamia felted coccid

This insect is spreading fairly wide in our region. It appears to have originated in a nursery in Barberton and then transferred to the macadamia orchards. These pests are easy to miss in an orchard and it spreads easily. The macadamia parasitoid will be the key to controlling this coccid, but there is no indication of when we will be able to use it.

Bark borers

There are many different species of these beetles that are not just confined to Macadamias. They occur in Balito, White River and Barberton areas. Their preferred hosts are stressed trees, but they are not limited to these trees. Each year the number of infested trees has grown, and it is not known why the numbers are growing. This growth in the number of borers is a worldwide concern and the reasons for it remains a mystery.

Conclusion

- New approaches to pest management are being developed that need to be embraced and not ignored.
- There is an appreciation that life needs to be brought back into the orchards and into the soils (insects and plants) – there is a need to restore what has been destroyed by pesticides.
- The use of sprays should be carefully timed to impact the pest insects selectively.
- There is a need to avoid the pesticide treadmill, and once having got off the mill the benefits will be manifest.
- Achieving sustainable pest control now will ensure that in 10 years time we have secure markets for the products.

What honeybees in South Africa need from people: better managed forage

By: Tlou Masehela

Honeybees are often in the news. Research constantly updates what's known about their importance to the environment, biodiversity, economies and food security. In South Africa, managed honeybees support livelihoods in various ways, such as honey production. In the last decade or so, pollination services to agriculture have also become a huge revenue area for beekeepers. It is estimated that honeybees pollinate over 50 crops in South Africa. In just one province, the Western Cape, about 91,000 hives are currently required to serve the deciduous fruit industry. And this number is expected to increase to at least 100,000 in the next five years. In February 2020, the government's beekeeper registration database recorded 77,088 managed hives for the province – more than 45% of the country's total of 161,610. If these numbers are accurate, then there is already a shortfall of hives in the Western Cape.

In a book chapter I co-authored with my colleagues, we outlined the importance of the two honeybee subspecies, *Apis mellifera capensis* (Cape honeybee) and *Apis mellifera scutellate* (African honeybee). We explored their importance for pollinating agricultural crops and indigenous plants, helping to maintain various ecosystem functions. These honeybees require a diverse quality and quantity of good forage resources to survive and produce. But those resources are under threat and need to be better managed.

The bee forage challenge

Studies conducted by the South African National Biodiversity Institute, between 2011 and 2014, found that beekeepers manage a variety of forage resources important to honeybees. Some are indigenous; others are exotic – such as forestry plantations, agricultural crops, garden plants and tree lanes in cities.

These various resources all have preferred and complementary uses and are all important. They may be best for honey flow, colony build-up, or swarm trapping, or be available at different flowering times and accessible to different users.

Therefore, an overarching strategy for managing forage resources has to consider indigenous and exotic plants, as well as use, availability and accessibility.

We note with great concern that honeybee forage resources are under increasing pressure in South Africa. Threats to forage availability and accessibility directly affect beekeeper livelihoods and pollination services. They put both wild and managed honeybee populations at risk.

Here are some of the threats.

- Changes in land use and landscape management. Changes and competing priorities resulting from bland use and its management, including agricultural practices, have been shown to threaten bee populations through habitat loss.
- Removal of invasive alien plant species that are important forage resources. Although invasive alien plants have a negative impact on biodiversity and ecosystem unctions, some of these plants also serve as important forage for honeybees. Managing them must take trade-offs into account.
- Accessibility to important and secure forage resources. Most beekeepers do not own the land where their hives are kept or where they can access forage. Permission to access good forage sites remains a challenge for beekeepers. This puts pressure on the foraging area and encourages overstocking, which may hinder hive productivity, increase competition with other pollinators and promote the transmission of diseases, pests and pathogens.
- Crop chemical regimes that affect the viability of crops. Various crops serve as important forage for bees, especially at times when natural vegetation might be out of flower. However, these crops are often subjected to heavy pesticide application to manage pests, and this can kill bees. Beekeepers are then reluctant to place hives in agricultural areas.
- Impacts of climate change. Extreme events associated with climate change, such as high frequency of fires and droughts, has an impact on forage and habitat for bees. Adverse changes in temperature also affect flowering, creating a mismatch in seasonal timing of when flowers produce adequate nectar and pollen for bees.

Planning and Action

Taking into account the projected pollination demands for years to come, there's an urgent need to plan for expansion and provision of forage resources for managed honeybees in South Africa.

In the Western Cape, a strategy for the industry was developed in 2017 with the assistance of the Western Cape Department of Agriculture. However, the plans are yet to take off, through lack of funding and, to some degree, political will to commit in the areas of demand. A public-private partnership is critical at this stage to plant and provide enough forage. Government needs to take leadership and responsibility, realising the importance of the beekeeping industry, and the services it provides to the agricultural sector – food production.

In our chapter, we put forward for consideration various management recommendations. A few are ready for action, while others still need to be developed further.

Raising awareness and building understanding. The public has to realise why the current situation needs to change. This process must be informed by facts and focus on the right target audience. It must also be monitored to ensure effectiveness.

Practices that protect existing forage resources. The goal is a viable and sustainable honeybee population. This must be a concerted effort among policy makers, agriculture and environmental sectors, researchers and the public at large.

Practices that promote planting of honeybee forage. The initiatives and practices around planting bee forage needs to happen on both public land and private land. There are successful campaigns to draw from internationally.

The pollination demands in agriculture are expected to keep rising. This means that more land and forage is required to feed the bees naturally. Hive theft and vandalism have increased tremendously in most areas across the country as hives are in demand for pollination. This adds to security costs for beekeepers. Beekeepers have started passing the cost of feeding and hive security to growers. They will no doubt pass these costs on to consumers.

Unlike some countries, South Africa is in no position to import any other species of bees for crop pollination. It's up to us to keep them alive for the continuous provision of pollination services.