Nut borers in South African macadamia orchards: the main culprit and research towards improving control

ASHLEIGH K. **SMITH**, PROF BERNARD **SLIPPERS**, PROF BRETT P. **HURLEY** AND DR GERDA **FOURIE**
(FORESTRY AND AGRICULTURAL BIOTECHNOLOGY INSTITUTE (FABI))

Nut borers are one of the major insect pests of macadamia. They are responsible for causing feeding damage as well as premature nut drop.

Despite the various products available for nut borer control, nut borer infestations continue to cause yield losses throughout South Africa. Biological control agents and pheromone-based products offer an alternative and eco-friendly approach for effective pest control. However, as these approaches are generally species specific, successful implementation requires identification of the key target species. A two-year survey was thus conducted and determined that the macadamia nut borer is the dominant species present in macadamia nuts in orchards in Mpumalanga, Limpopo, and KwaZulu-Natal. We are currently working on characterising the sex pheromone composition of macadamia nut borers in order to improve the accuracy of pheromone-based products.

Moths and butterflies comprise the second largest insect order following beetles, and they are notorious pests on a wide host range of plants including macadamia (Culin, 2018). The larval stage is responsible for causing yield losses in macadamia since the larvae feed and develop within the pericarp and, occasionally, depending on the stage of nut development, within the kernel (Fig 1). Although the economic impact of yield losses resulting from nut borer damage has not been quantified in South Africa, infestations have been recorded throughout the three main macadamia growing provinces, namely Mpumalanga, Limpopo, and KwaZulu-Natal (Timm, 2007; Schoeman et al., 2009).

Pheromones are chemicals secreted by insects which insects use to communicate with each other, and affect the behaviour of other individuals of the species

Figure 1. Nut borer damage to macadamia.

The long-term sustainability of the macadamia industry is dependent on the implementation of effective integrated pest management strategies and the associated reduction in kernel loss. With the global trend towards reducing pesticide usage and the strict regulation of maximum residue limits (MRL) in macadamia, eco-friendly and effective control alternatives are essential (Ambrus & Yang, 2016). Biological control agents and pheromone-based products are becoming increasingly attractive. However, in order to develop these products, extensive knowledge of the target pest is required.

The dominant moth pest

In South Africa, the false codling moth or FCM (*Thaumatotibia leucotreta*), macadamia nut borer or MNB (*Thaumatotibia batrachopa*), litchi moth (*Ectomyelois ceratoniae*) and the carob moth (*Cryptophlebia peltastica*) have been previously reported as the four main nut borer pests of macadamia (Timm, 2007; Schoeman et al., 2009). The comparative importance or dominance of those moths was uncertain; knowledge that is important for control methods such as the use of biological control agents and pheromone-based products that are generally species specific. We therefore conducted a survey throughout the three main growing provinces between 2017 and 2019 in which moth larvae were extracted from macadamia nuts and identified through genetic barcoding. We determined that over 95% of the larvae were MNB (Fig 2) (Smith, 2020). During the survey, only five FCM larvae were identified (Fig 3), while no litchi moth or carob moth larvae were identified from macadamia nuts despite having collected over 1000 larvae (Smith, 2020). These findings suggest that MNB is the dominant moth pest within these regions and that control strategies should mainly be focused on reducing MNB populations (Fig 4).

Bearing in mind the dynamic nature of ecosystems, and that species presence may vary throughout or between seasons, the continuous monitoring of pest populations is required to enable the adaptation of control regimes and successfully target the main threat. Moth identification based on morphology can be tricky, particularly with early instar larvae or degraded specimens (Fig 5), while identification through genetic barcoding is time-consuming and expensive. We therefore developed molecular tools for rapid identification of MNB, FCM, litchi moth and carob moth in a single reaction (Smith, 2020). These tools provide a means to monitor the fluctuation of pest populations within macadamia orchards.

Figure 2. Various developmental stages of macadamia nut borer larvae.

Figure 3. False codling moth larvae.

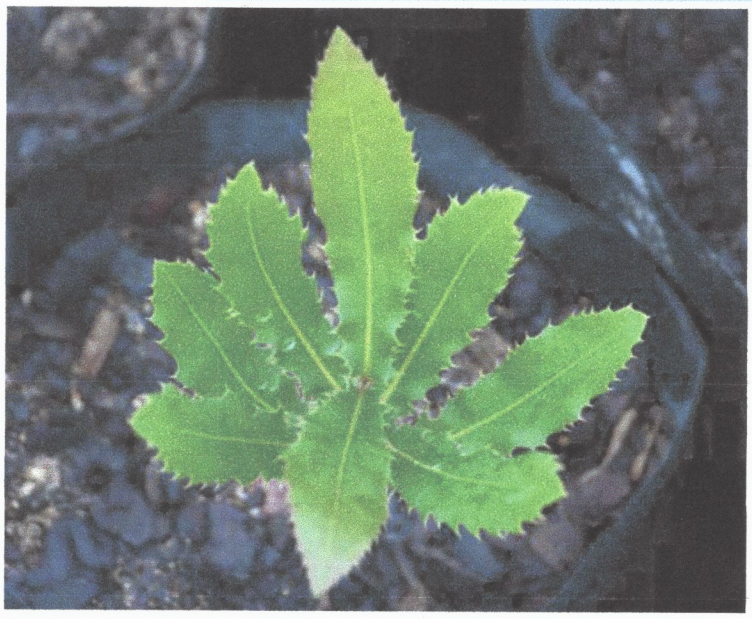
Figure 4. Adult stage of macadamia nut.

We encourage growers to submit larvae to the FABI Diagnostic Clinic for identification (https://www.fabinet.up.ac.za/index.php/disease-diagnostic-service).

Figure 5. Degraded larval specimen.

MNB sex pheromone

Although pheromone-based products are available for MNB, it is possible that the pheromone used within these products may need to be improved to increase capture rates and species specificity. Personal communication with farmers from our survey suggested that the dominance of MNB larvae found in nuts did not always correspond to the dominant moth species found in the pheromone-based monitoring traps. Oftentimes higher moth counts were recorded



from FCM monitoring traps as opposed to MNB monitoring traps. Furthermore, we obtained a number of adults from both MNB and FCM monitoring traps as well as moth species other than the intended target, indicating that trap accuracy should be further evaluated. Part of our ongoing research involves additional identifications of moths captured in MNB and FCM monitoring traps to corroborate results obtained from our pilot study.

The pheromone component used in MNB targeted products was identified in the 80s as the major sex pheromone component of MNB (Hall et al., 1984), which is also a known sex pheromone component for many other moth species (Cardé et al., 1979; Chang, 1995). However, subsequent research has shed light on the complexity of pheromone communication in moths, where sex pheromones consist of a blend of both major and minor components in a particular ratio in order to attract a suitable mate of the same species (Groot et al., 2014). Our current research aims to identify all components of the MNB sex pheromone as well as the optimal blend ratio for moth attraction. These findings will facilitate the development of more effective products for monitoring and control of MNB. We are excited to contribute towards the success of the South African macadamia industry in a sustainable and environmentally friendly way.

Acknowledgments

We thank the farmers involved in this study for providing numerous samples and access to survey sites. We would also like to acknowledge the University of Pretoria, the Forestry and Agricultural Biotechnology Institute (FABI), the DSI Centre of Excellence for Tree Health Biotechnology (CTHB), Macadamias South Africa NPC (SAMAC) and NRF Thuthuka for financial support.

References:

Ambrus Á, & Yang Y. (2016). Global harmonization of maximum residue limits for pesticides. *Journal of Agricultural and Food Chemistry* **64**: 30-35.

Cardé AM, Baker TC & Cardé RT (1979). Identification of a four-component sex pheromone of the female oriental fruit moth, *Grapholitha molesta* (Lepidoptera: Tortricidae). *Journal of Chemical Ecology* **5**: 423-427

Chang VCS (1995). Trapping *Cryptophlebia illepida* and *C. ombrodelta* (Lepidoptera: Tortricidae) in macadamia in Hawaii. *International Journal of Pest Management* **41**: 104-108

Culin J (2018). *Lepidopteran*, Britannica. (https://www.britannica.com/animal/lepidopteran)

Groot AT, Schöfl G, Inglis O, Donnerhacke S, Classen A, Schmalz A, Santangelo RG, Emerson J, Gould F, & Schal C (2014). Within-population variability in a moth sex pheromone blend: genetic basis and behavioural consequences. *Proceedings of the Royal Society B: Biological Sciences* **281**: 20133054.

Schoeman PS (2009). Key biotic components of the indigenous Tortricidae and Heteroptera complexes occurring on macadamia in South Africa. Doctoral thesis. University of Potchefstroom, North-West Provence, South Africa

Smith A (2020) Characterisation of Lepidoptera species associated with Macadamia in South Africa Masters dissertation. University of Pretoria, Gauteng Provence, South Africa.

Timm AE, Warnich L, & Geertsema H (2007). Morphological and molecular identification of economically important Tortricidae (Lepidoptera) on tropical and subtropical fruit in South Africa. African Entomology **15**: 269-286.