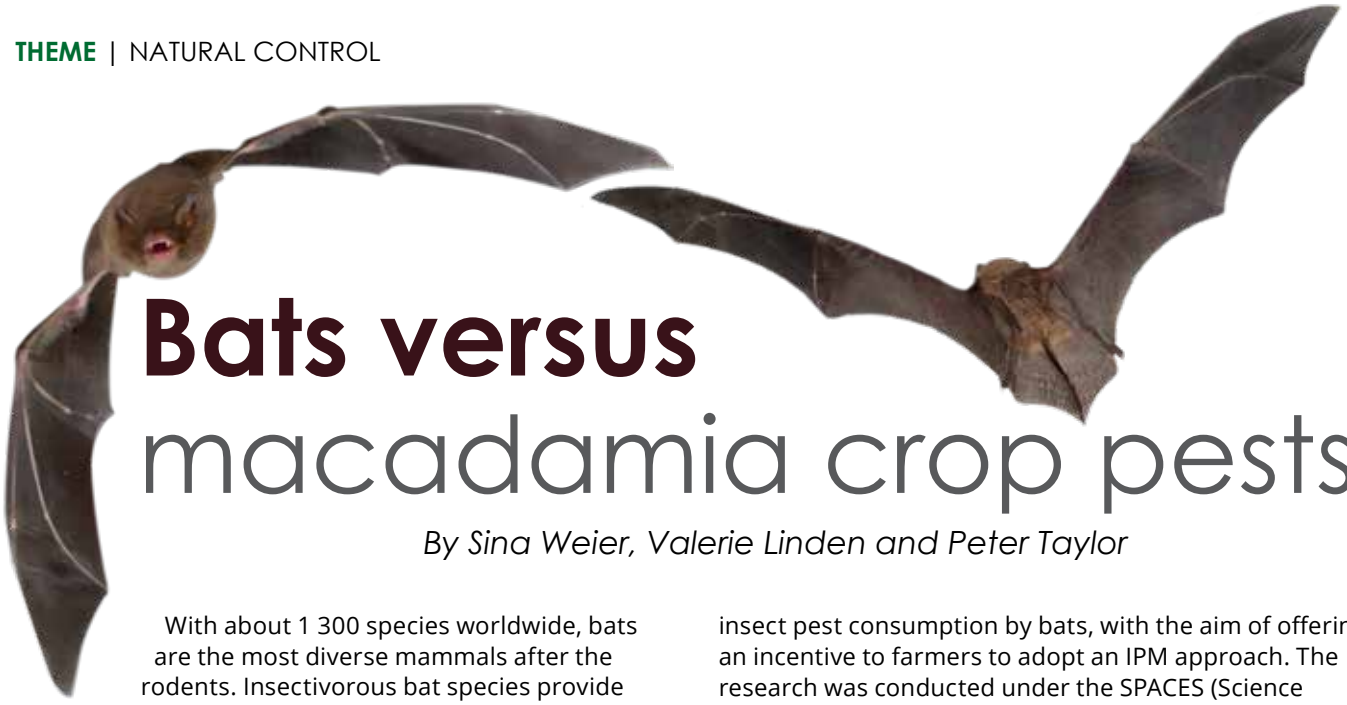

Bats versus macadamia crop pests

By Sina Weier, Valerie Linden and Peter Taylor

With about 1 300 species worldwide, bats are the most diverse mammals after the rodents. Insectivorous bat species provide an important ecosystem service to farmers around the world by reducing numbers of insect pests in agricultural areas. Promoting high bat activity in agricultural landscapes as part of an integrated pest management (IPM) approach could not only improve the livelihood of farmers, but also potentially decrease the use of pesticides without losing crop. Unfortunately, bat populations keep declining at an alarming rate and about one quarter of all bat species are currently threatened with extinction. This decline is mainly attributed to the loss and fragmentation of habitats, roost sites and feeding opportunities, caused primarily by agricultural intensification – more and more natural areas being turned into farmland.

South Africa has been the world's largest producer of macadamia nuts since 2014, and the loss from insect pest damage to the macadamia crop is estimated at about US$15.23 million per year. In 2015 the University of Venda started several projects to provide evidence of insect pest consumption by bats, with the aim of offering an incentive to farmers to adopt an IPM approach. The research was conducted under the SPACES (Science Partnership for the Assessment of Complex Earth Systems) consortium, with funding received from the German Federal Government and collaboration with the University of Goettingen in Germany. The study sites were in macadamia orchards in Levubu, Limpopo, where an estimated 25 different insectivorous bat species occur.

Initial research focused on investigating the diet of insectivorous bats in more detail. Given that bats hunt at night and in flight, it is very difficult to study their diet and nearly impossible to study their feeding behaviour by observing them directly. But studying their faecal pellets – either under a microscope or through molecular work in a laboratory – provides a non-invasive way of gaining information on the foraging preferences of these predators. The research team at the University of Venda decided to use fluorescently labelled primers to show the presence of four of the main insect pests in bat faecal pellets: the twin-spot stinkbug *(Bathycoelia distincta)*, the green vegetable bug *(Nezara viridula)*, the macadamia

Macadamia nuts are enclosed in a green husk that splits open as the nut ripens.

Initial research into the installation of bat houses to provide additional roosting opportunities showed that insectivorous bat species prefer houses that are warm and well insulated.

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Mauritian tomb bat and pup.

nut borer *(Thaumatotibia batrachopa)* and the litchi moth *(Cryptophlebia peltastica)*. The first two are stinkbugs that feed directly on macadamia nuts, while the second two are moths that lay their eggs on the young macadamia fruit, into which the larvae bore after hatching. Apart from leading to a decrease in nut quality, the feeding damage can cause nuts to drop immaturely, germinate or grow mould.

Interestingly, all the species or families of bats from which pellets were collected foraged on at least one of the four main insect pests, and pests were found in more than half of the samples. Nearly all species and families of bats analysed foraged on both the moth and the stinkbug insect pest species. Bats consumed insect pests throughout the macadamia growing season, and are much more generalist − and presumably opportunistic − feeders than previously assumed. The research conclusion was that bats appear to be of utmost importance for insect pest control.

Other studies conducted by the University of Venda, looking into habitat use by bats, showed that the overall activity of bats increased with the abundance of true bugs (which include the main macadamia pests, the stinkbugs) and the amount of natural vegetation close to the macadamia plantation. The study further showed that semi-natural vegetation, such as fallow land, increased the activity of a certain group of bats, which preferably forage above vegetation and in open areas. As part of the project, bats and birds were also excluded from macadamia trees by putting up cages around the trees. The researchers found that the biocontrol provided by both insectivorous bats and birds saves macadamia farmers around US$5 000 per hectare each year, which is economically more important than the losses through crop-raiding by monkeys (~US$1 600 ha/year). Both the biocontrol provided by bats and birds and the crop-raiding by monkeys were linked to the vicinity of natural vegetation patches.

The research team therefore suggests that farmers should maintain or restore (semi-) natural vegetation inside and adjacent to their farms. Adding water sources and roosting opportunities, as well as minimising pesticide treatments, may also help promote bat activity and the biocontrol provided by them.

Dr Sina Weier and Dr Valerie Linden were awarded their PhDs in zoology for this research in May 2019 by the University of Venda (Univen), where they are both now postdoctoral fellows. Prof. Peter Taylor supervised their research, and holds the SARCHi Chair in Biodiversity Value and Change in the Vhembe Biosphere Reserve.