ECO VINEYARDS
GROWING RESILIENCE NATURALLY

FACT SHEET

THE ROLE OF MICROBATS IN AND AROUND VINEYARDS

By Dr Zenon Czenze, Dr Heidi Kolkert, University of New England and Dr Mary Retallack, Retallack Viticulture Pty Ltd

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MICROBATS ARE AN IMPORTANT PREDATOR OF GRAPEVINE INSECT PESTS

Bats are flying mammals of the order Chiroptera. Their forelimbs are adapted as wings and they are the only mammals capable of sustained flight. Not all bats are the same and they have vastly different roles in the ecosystem.

Bats are split into two major groups:

- **Megachiroptera, or fruit-eating 'megabats', which include flying foxes and fruit bats, and**
- **Microchiroptera, or insect-eating 'microbats', which may only weigh 3 to 5 grams, or about the same as a teaspoon of water, and measure up to 11 cm in length.**

In Australia, there are over 80 species of bat and 69 species are microbats, which are important pest controllers.

DID YOU KNOW THAT MICROBATS CAN EAT 30 TO 100% OF THEIR BODYWEIGHT IN PEST INSECTS EVERY NIGHT INCLUDING LIGHT BROWN APPLE MOTH (LBAM)!

Figure 1. *Nyctophillus geoffroyi*, lesser long-eared bat (left), and *Vespadelus vulturnus*, little forest bat (right), are common microbats found in vineyards across Australia, pictured at Fowles Wine, Strathbogie Ranges, Victoria [Photos: Colin Page].

In other parts of the world, microbats play a crucial role in vineyards. In the Bordeaux region of France, microbats help control grape berry moth.

The team at INRA found up to 70% of bat scats tested positive for the presence of *Lobesia botrana*, European grapevine moth, and contribute towards the control of these leafrollers (Roush, 2019). Across southwestern Europe and the Iberian Peninsula, microbats are effective insect hunters, preying on various pests, including those affecting grapevines.

Microbats adjust their diet with the seasons, showcasing their adaptability; trees that are left standing in vineyards serve as valuable homes for microbats, improving their foraging, providing cover, and enhancing connectivity. This creates a win-win situation for both microbats and vineyards.

Figure 2. Trees left in and around vineyards provide valuable habitat for microbats, especially mature trees with hollows present. Or if they are not available microbat boxes installed > four metres above the ground can provide supplementary habitat [Photo: Mary Retallack].

In Australian cotton farms, microbats play a crucial role by preying more on agricultural pests than non-pests. This suggests a valuable service in pest regulation, estimated to be worth nearly AUD $63.6 million.

Interestingly, this assessment has been specifically quantified for cotton, making it the only Australian crop where the economic value of natural pest control by microbats has been measured. In cotton fields, pests are most active in spring and summer. Microbats flying over cotton fields change their diet during this time to include an estimated 65% of pest insects (Kolkert et al., 2021).

Similarly, in vineyards, the peak occurrence of pests aligns with the highest activity and diversity of microbats during the spring and summer months (see **Figure 3**).

Given that Australian cotton and wine industries share various insect pests, including *Agrotis* spp. cutworms; *Helicoverpa* spp., budworms; *Spodoptera frugiperda*, fall armyworm; and other moths, it is likely that microbats could provide a similar natural pest control service to vineyards.

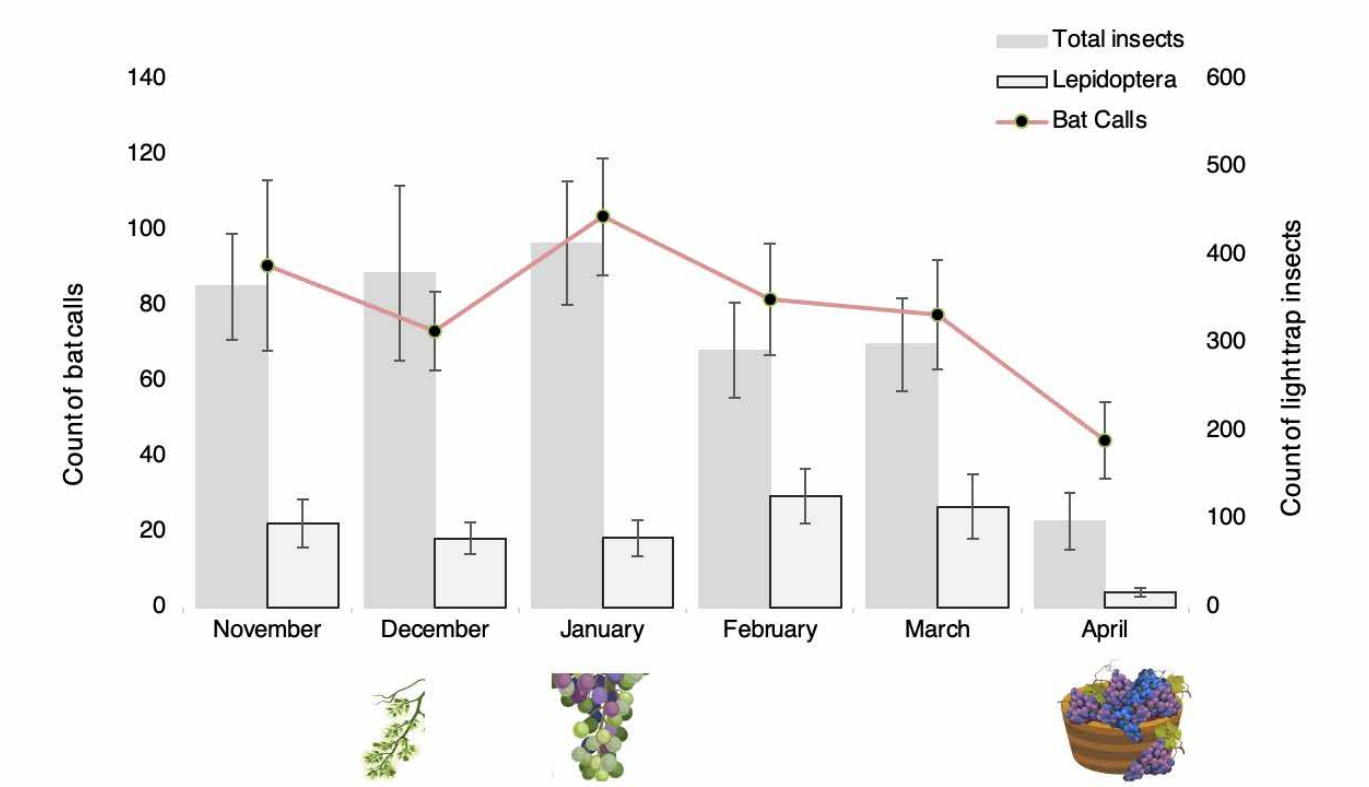

Figure 3. Average bat calls recorded during the grape growing season against total light trap insect collections and lepidoptera light trap collections. Preliminary data from the New England Tableland bioregion of NSW during the 2022-2023 growing season (09/11/22 – 15/04/23) at two wineries.

In Australia, microbats may feed on *Phalaenoides glycinae*, grapevine moth, *Echiomima* sp., vine borer moth, *Xylopsocus gibbicollis*, common auger beetle, *Xyleborus dispar*, fruit-tree borer, and *Epiphyas postvittana*, light brown apple moth (LBAM). Considering the potential benefits, Australian microbats could be valuable allies against these pests as they naturally prey on similar insects.

In Australian cotton agroecosystems, pest control by bats is estimated to be $361 per hectare. With approximately 150,000 ha of vineyards in Australia, a similar level of pest control would equate to an ecosystem service worth nearly AUD $53 million annually.

Similarly, LBAM is the principal insect pest that causes economic damage in Australian vineyards. It causes damage to flower clusters, resulting in yield losses and damage to berry skins. Damaged skins provide infection sites for *Botrytis cinerea* and other bunch moulds, which may result in a reduction in fruit quality and yield losses (Ferguson, 1995).

Annual losses from Botrytis and other bunch rots and LBAM were estimated at $52 million and $18 million, respectively (Scholefield and Morison, 2010).

Therefore, if LBAM can be effectively managed using biocontrol options, including microbats, predatory arthropods, parasitic wasps, insectivorous birds, and improved vine health, it is possible to reduce the combined national economic impact by $70 million per annum.

Monitoring for the presence of microbats

Microbats typically navigate by echolocation although they also have excellent eyesight. They emit high frequency pulses of sound through their mouth or nose that bounce off surfaces and objects around them. Bats pick up the echoes of these sounds with the aid of their extraordinary ears and use this sonar signal to locate where they are in the landscape and what is flying in front of them.

The timing, loudness, and direction from which the echo arrives at each ear indicates the direction and distance of the object. By installing acoustic detectors in a vineyard and/or the surrounding landscape, growers can help investigate the role of microbats in Australian vineyards.

Figure 4. Examples of devices used to detect microbat activity, including Wildlife Acoustics Song Meter Mini Bat (left), and Wildlife Acoustics Echo Meter Pro 2 attached to a mobile phone (right) [Photos: Colin Page].

Microbats could unveil a natural solution to the challenges posed by insect pests and offer an eco-friendly strategy for integrated pest management.

The consumption of insects in vineyards by microbats helps to reduce the need for pesticides, and this presents a clear economic benefit for landowners.

On-farm revegetation and ecological restoration, especially in degraded farming areas where there is a source of water, can create favourable habitats for microbats, leading to higher microbat population densities and ecosystem benefits. Microbats in Australia are facing environmental challenges, including habitat loss and overheating.

Many Australian microbat species rely on tree hollows, but activities like land clearing and destruction of hollow-bearing trees, particularly in agroecosystems, have led to declines in microbat populations. Disturbingly, 43% of microbat species in NSW are now listed as threatened under the NSW Biodiversity Conservation Act 2016.

Recent research

During the 2022-23 growing season at two vineyards in NSW, 21 bat species were confidently identified using acoustic detectors.

However, most calls were recorded from three functional groups:

- *Chalinolobus* ssp., wattled bats (53% of total calls)
- *Vespadelus* ssp., forest bats (24%)
- *Nyctophilus* ssp., long-eared bats (10%).

Species within these three groups are common throughout Australia and mainly feed on moths. They require habitat that includes hollow bearing trees or trees with exposed or sloughing bark.

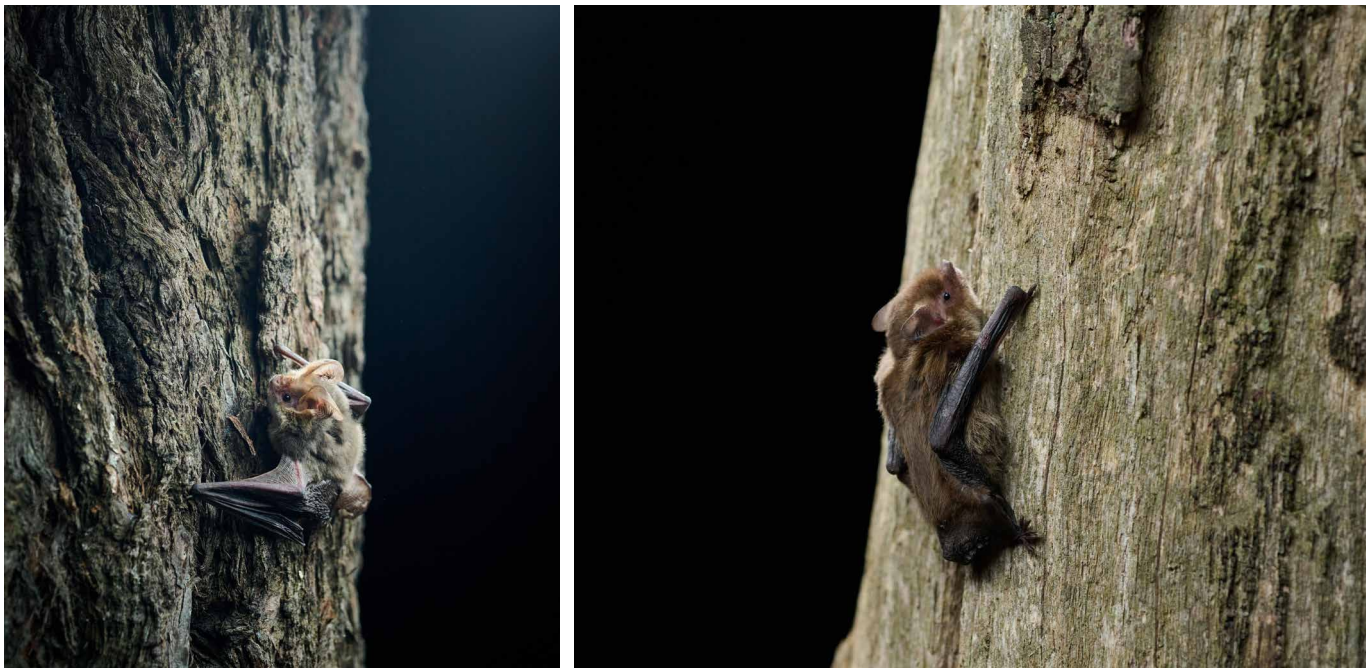

Figure 5. Most bats in vineyards require hollow bearing trees or those with exposed bark *Nyctophilus geoffroyi*, lesser long-eared bat (left), and *Vespadelus vulturnus*, little forest bat (right) taken at Fowles Wine [Photos: Colin Page].

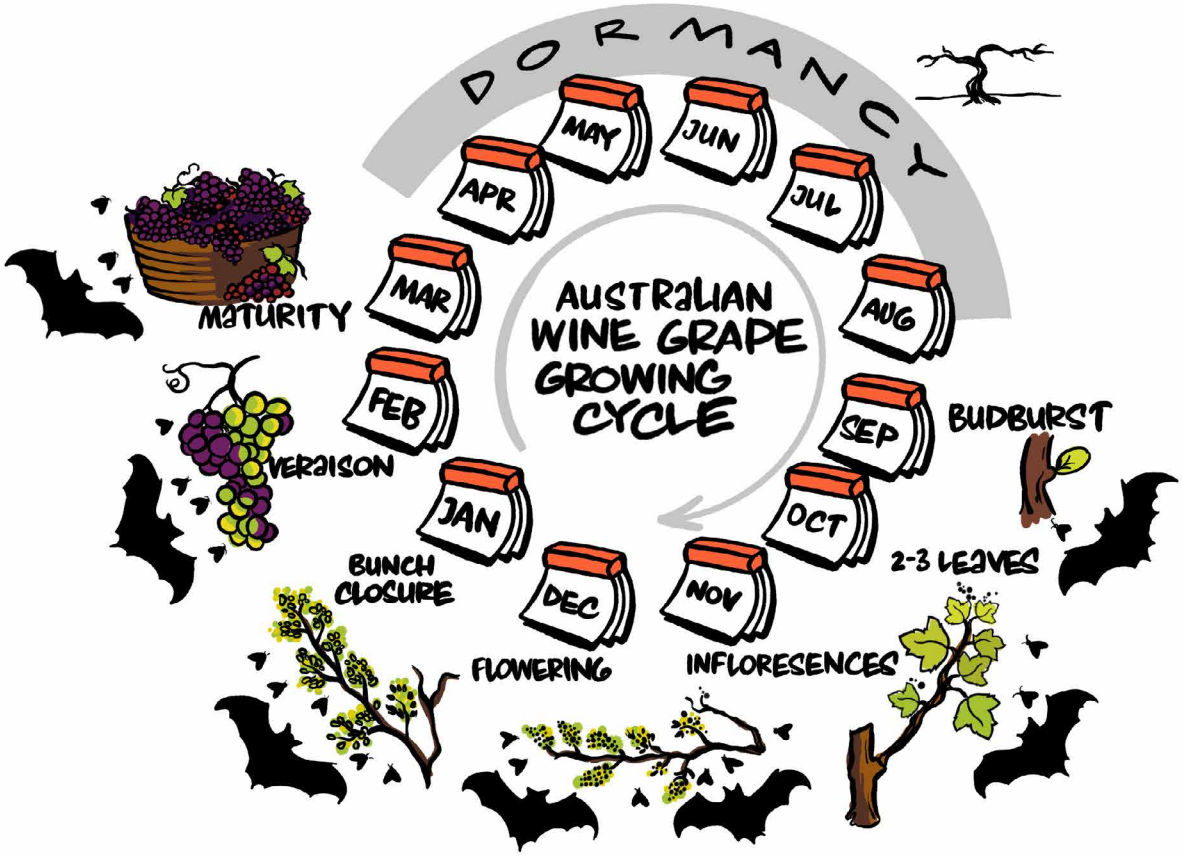

Figure 6. Bat and insect activity in the New England Tableland bioregion of NSW during the during the 2022/23 growing season

Although most calls recorded during the growing season were from common bats that have previously been associated with other agriculture, there were eight species listed under the Biodiversity Conservation Act 2016.

This list is restricted to vineyards in the New England tablelands, and growers across Australia may have several additional threatened species on their property. We recommend that growers undertake acoustic surveys to determine which bat species are present and encourage the protection of native vegetation adjacent to vineyards.

Several species of bats have been captured and recorded in vineyards. Threatened species are likely also using vineyards as habitat and foraging ground and acoustic surveys should be undertaken.

Table 1. Threatened bat species identified through acoustic detection in vineyards within the New England Table Land Bioregion.

Species name	Common name
Chalinolobus dwyeri	large-eared pied bat
Chalinolobus picatus	little pied bat
Falsistrellus tasmaniensis	eastern false pipistrelle
Miniopterus australis	little bent-wing bat
Miniopterus orianae oceanensis	Australasian bent-wing bat
Saccolaimus flaviventris	yellow-bellied sheath-tailed bat
Scoteanax rueppellii	Rüppell's broad-nosed bat
Vespadelus troughtoni	eastern cave bat

Microbat habitat

Recent research shows that microbats in Australian vineyards are influenced by different factors. These include where the vineyard is located, how close it is to natural vegetation, and the stage of crop growth. However, one critical factor appears to be the quality and amount of nearby natural vegetation.

Vineyards with more natural vegetation around them, especially those with a higher ratio of vegetation to the vineyard itself (like long, narrow fields or small fields), tend to have more microbats.

Figure 7. Microbat monitoring sites in NSW and the proximity of native vegetation near the sampling sites [Google Earth].

Having more remnant vegetation could also help control pests in a larger area of the vineyard, offering a more natural way to keep insects in check. Additionally, having more native habitat around can help protect species of microbats that are in danger.

The remnant vegetation around vineyards plays a big role in determining what kinds of insect-eating microbats live and forage near vineyards (**Figure 7**).

For example, preliminary data from NSW during the 2022-23 growing season showed that bat activity was 11 times higher in a vineyard with remnant vegetation comprising small pockets of mature *Eucalytpus melliodora*, yellow box; *E. blakelyi*, Blakely's red gum; and stringybark species compared to another with primarily cleared agricultural land with mainly isolated paddock trees – *Eucalyptus melliodora* and *E. dalrympleana*, mountain gum – remaining.

Vineyards bordered by remnant forest can have more than 10 times the bat activity than completely cleared lands. Revegetation initiatives can help connectivity between forest patches and potentially increase bat numbers.

Edge habitat (the boundary between the vineyard and the adjacent habitat) supports the most invertebrate numbers and species, particularly moths.

Arthropod richness and abundance are known to be greatest along edge habitat in many cultivated crops, favouring generalist predators like most bats species that can easily travel along the crop. Centre habitats are not as ecologically dynamic as edge habitats and provide more 'stable' environments.

The lower abundance and richness of arthropods in the centre of the vineyard supports only specialist high-flying microbats.

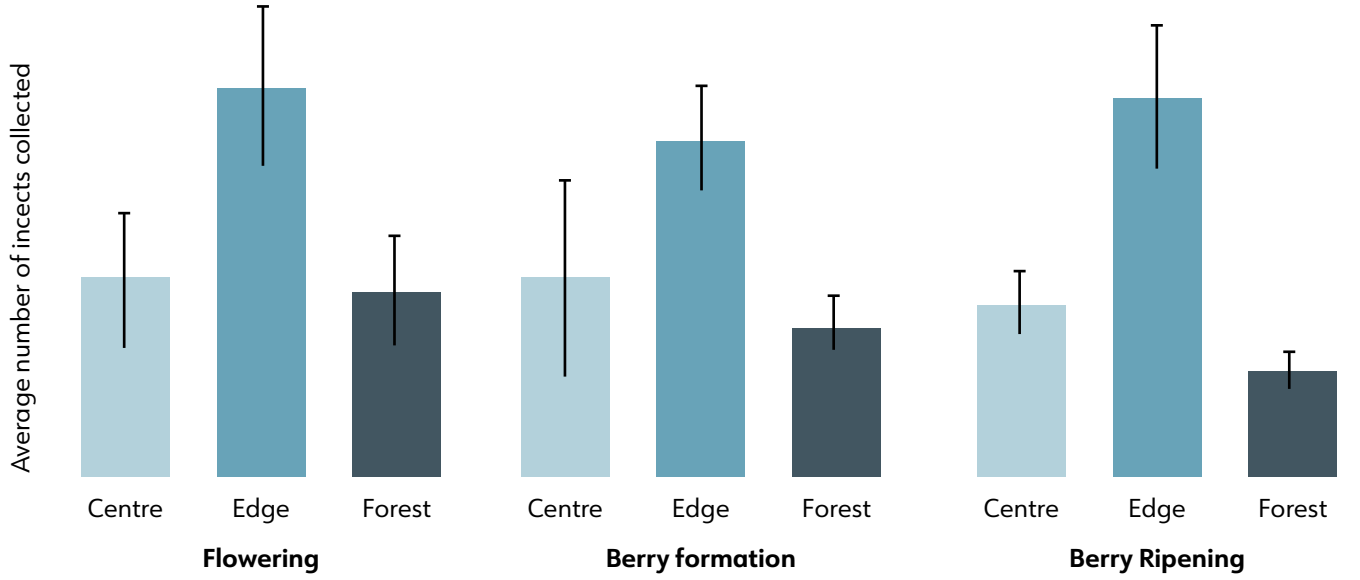

Figure 8. Mean number of arthropods (± SE) captured weekly in light traps over crop stages (flowering, berry formation, and berry ripening) across treatments (vineyard centre, vineyard edge, remnant forest).

Understanding how insect diversity changes at the vineyard edge and centre over the growing season can assist with IPM. As microbats target preferred prey species, they are likely to provide an important pest control service over the grape growing season as insect pests irrupt.

Manipulating habitat in the vineyard may facilitate many species of microbats to forage further inside the vineyard. This could be achieved by establishing vegetation 'acoustic markers' (strips or groups of taller shrub and tree habitat every 50 metres) along a vineyard row.

Within a crop, it appears that the most species of bats are recorded on the edge near remnant forest or stands, and are most likely taking advantage of the high number of arthropods. As the crop grows, especially in the outer edges of the vineyard, it seems that insect-eating microbats, especially those that like to hang around the edges, spread out across the whole vineyard. When remnant forest is unavailable microbats appear to target this habitat type.

Although the edge is the most active in the crop, notice the difference in Figure 9 between the number of calls in edge and remnant forest. This highlights the importance of remnant forest adjacent to vineyards. However, even when remnant forest is limited bats appear to be very active on the crop edges and can likely be increased by installing artificial roosts for bats.

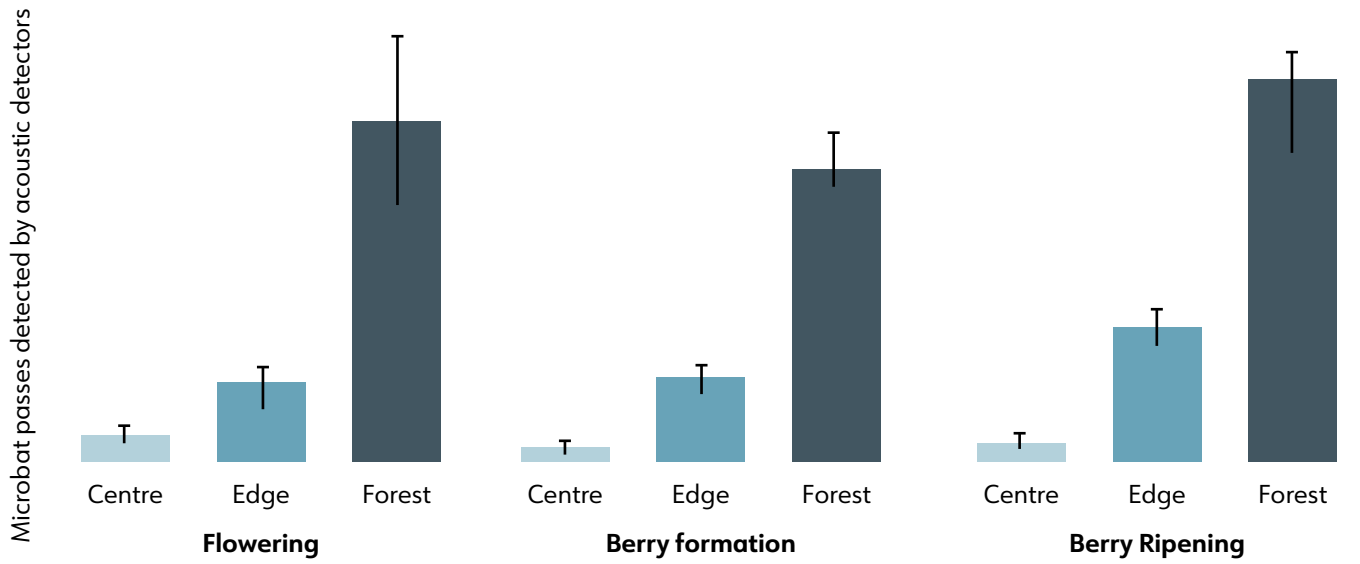

Figure 9. Mean number of insectivorous microbat passes (± SE) recorded over crop stages (flowering, berry formation, and berry ripening) across treatments (vineyard centre, vineyard edge, remnant forest).

Even though the bats may be most active on the edge of vineyards, they require roosting habitat like hollows or exposed bark of trees near the vineyard edge.

For grape growers to harness the natural pest control benefits of microbats, having the right habitat on forest edges is crucial. However, there's often a shortage of hollow-bearing trees to support large microbat populations. This is especially important for lactating females and pups as they are vulnerable to overheating.

Microbat boxes

It is most important to place artificial habitat in the shade as microbats can overheat during the summer. It is recommended to place microbat boxes in a north to north-westerly aspect or easterly aspect (avoiding a westerly orientation).

Several supplementary habit structures in close proximity but at different aspects on the same tree or structure will give the microbats choice to select the best option, depending on seasonal conditions.

It is important to select an appropriate area to install your microbat boxes:

- **Select an area where bats can be seen emerging in the evening and for ease of access.**
- **Microbat boxes should be installed 4 to 6 m above the ground (where possible) to protect the bats from predators, although they are quite happy rousting in the eaves of sheds.**
- **Find a mature tree with a minimum diameter of 30 cm (buildings and poles can also be effective). Select areas where there are no branches that will obstruct their flight path.**
- **Install two boxes on the same tree with different aspects (primarily NW to SE facing) as this increases the chance of habitation by giving the bats different options based on temperature (avoid installing dark coloured boxes facing west as they can get hot in summer).**
- **Microbats may use several roost sites located a short distance from one another and may change roost sites daily in response to temperatures, parasites, and to avoid predators.**

Don't handle microbats as they can carry Australian Bat Lyssavirus (ABLV), a virus, like rabies, that can be transmitted from bats to humans.

Figure 10. Microbat boxes installed in trees to create supplementary habit for microbats [Photo: Mary Retallack].

Despite their size, microbats are voracious, hard-working insect predators. Early results from faecal analyses of scats shows that not only are microbats living near vineyards but feeding in them too. Cutting-edge DNA sequencing of bat faeces revealed that bats in a NSW vineyard consumed over 160 different prey items from six insect orders.

However, the overall diet of all bats was dominated by moths and flies. Encouragingly, it appears that bats are indeed consuming agricultural pests, but more research from more vineyards is required. By understanding how microbats contribute to pest control, we can develop strategies for managing pests in a more integrated way. This information may also be instrumental in conserving critical habitats around vineyards, assisting growers in achieving their environmental stewardship objectives.

Figure 11. *Nyctophilus geoffroyi*, lesser long-eared bat (left), and *Vespadelus vulturnus*, little forest bat (right) [Photos: Colin Page].

Some bats can eat their entire body mass in insects every night. If you crunch the numbers, a colony of 100 x 10-gram females may consume up to 1 kilogram of insects each night!

Remember, the most significant threat to bats is habitat clearance, particularly the removal of the old forest wood where they roost in hollows or under the bark of trees.

TAKE HOME MESSAGES

- Over 20 species of microbats are living near or foraging in Australian vineyards. They are eating insect pests, particularly around the crop edge during the entire growing season.
- They consume agricultural pests, but more research is needed to quantify the economic value of their cost-free insect control. Growers should consider undertaking acoustic surveys to determine the diversity of bats on their land.
- There is no one-size-fits-all solution to increase bat numbers, but management priority should include protecting all trees on/adjacent to the vineyard as critical bat habitat. Revegetation may be an effective way to increase pest control by bats in the crop and properly placed artificial roosts may serve to recruit more bats to the area.
- Bats are your friends - natural pest control by bats may serve as an eco-friendly technique to help reduce insects in the vineyard without relying on chemicals.

If you are interested in being part of the Bats and Wine Project, which is conducting new research in Australian vineyards, please contact Dr Zenon Czenze, zczenze@une.edu.au, or Dr Heidi Kolkert, hkolker2@une.edu.au

REFERENCES

Ferguson K.L. (1995) Association of Botrytis bunch rot with light brown apple moth, The University of Adelaide, Adelaide.

Kolkert H., Smith R., Rader R., Reid N. (2021) Insectivorous bats provide significant economic value to the Australian cotton industry. Ecosystem Services 49:101280. DOI: 10.1016/j.ecoser.2021.101280.

Roush A. (2019) Meeting with Adrien Roush at INRA, in: M. J. Retallack (Ed.), Retallack Viticulture Pty Ltd, Bordeaux.

Scholefield P.B., Morison J. (2010) Assessment of economic cost of endemic pest and diseases on the Australian grape and wine industry. GWR 08/04, Grape and Wine Research and Development Corporation, Adelaide.

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