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Bulldozers and blueberries: managing fence damage by bare-nosed wombats at the agricultural–riparian interface

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Abstract: Fence damage by bare-nosed wombats (*Vombatus ursinus*) can be a serious problem for farmers wishing to reduce herbivory by other herbivores on valuable crops. We investigated the effectiveness of exclusion fencing to prevent the incursion of unwanted native and feral herbivores and the use of swinging gates designed to allow wombats to pass through the fence without having to damage it. We also examined the temporal response of animals toward exclusion fencing and wombat gates. The 10-month study took place on the interface between natural riparian vegetation and a 22-ha blueberry (*Vaccinium corymbosum*) orchard in southeastern Australia. Following the testing of exclusion fencing (i.e., footing wire and flexible fence), we installed 6 swinging wombat gates at existing breach points within the exclusion fencing. Wombat gates were 0.6 m high × 0.5 m wide and constructed of 200 × 100 × 6 mm galvanized steel. We continually observed the response of wombats and other animals to both exclusion fencing and wombat gates using heat- and motion-sensing digital cameras. We made a total of 1,480 detections of the 3 target species—wombats, red foxes (*Vulpes vulpes*), and swamp wallabies (*Wallabia bicolor*)—in the study area between August 2007 and June 2008. Most were wombat detections (79%), followed by detections of swamp wallabies (12%) and foxes (8%). Wombats became accustomed to using the gates within 1 month, with an average exclusion rate of 48% in the first month after their installation. For the final 6 months of the project, the number of wombat detections showed an exclusion rate of approximately 25%. The swinging gates were equally consistent in excluding foxes and wallabies. The results of this study showed that swinging wombat gates were effective in regulating access by wombats while excluding other unwanted animals.

Key words: exclusion fencing, exclusion rate, human–wildlife conflicts, swinging gates, wombats

Farming usually simplifies the existing vegetation, rendering the local environment unsuitable for many indigenous species (Dickman, 2008). Some species, disadvantaged by the changed conditions, are forced to retreat to less suitable habitats elsewhere (Southgate 1990), whereas others may persist *in situ,* but at much reduced population densities. In contrast, some species thrive on the elevated productivity provided by new monocultures and, thus, become pests (Singleton et al. 1999). Predators may in turn be attracted to the new food resource, drastically altering the predator–prey interactions in the surrounding landscape (Shapira et al. 2008). As a result, farms and orchards pose challenges to land managers who need to balance the conservation of wildlife species and their habitats with an increasing demand for agricultural production (Green et al. 2005).

The problem of pest control often is approached using lethal techniques, but concerns about the humaneness of such techniques increasingly are stimulating new ways of limiting levels of damage (Hone 2007). Exclusion fencing provides a good example. This technique typically is used to reduce damage to crops by pests (Poole et al. 2004), protect threatened species (Moseby and Read 2006), enhance forestry protection (Di Stefano 2005), and minimize environmental damage (Reidy et al. 2008). Exclusion fences, however, can be costly to erect and maintain and seldom are impenetrable, despite recent innovations in fence design (Robley et al. 2007, Bode and Wintle 2009).

A little-studied example of wildlife impact on agricultural resources is native bare-nosed wombats' (*Vombatus ursinus*) damage to fencing that adjoins their habitat (Breckwoldt 1983, Marks 1998). Wombats are known as bulldozers of the bush (Morecroft 2003) because of their low center of gravity and great strength. Historically, wombats have been culled by farmers in many parts of their range because of the damage they cause to fencing (Matthams 1921). In New South

Wales, permits for destruction of wombats are issued to prevent fence damage (Temby 1998). Wire netting fences, often installed at the riparian interface to both exclude cattle from entering the riparian zone and prevent wombats from accessing agricultural land, provide no barrier to wombats, which are able to scratch under the base of the fence and lift it to access grasses for forage on the other side. These activities create permanent holes and access points not only for wombats but also for many other species, including red foxes (*Vulpes vulpes*) and swamp wallabies (*Wallabia bicolor*). In rural Australia, foxes kill native animals and lambs and spread noxious weeds (Adams 2009). Wallabies are generalist browsers (Hollis et al. 1986, Osawa 1990), and foraging wallabies have been blamed for considerable losses of pasture and crop produciton (Statham and Statham 2009).

In rural southeastern Australia, few options for nonlethal wombat management are available to landholders, and only two, electric fencing and wire netting, have been tested (Marks 1998). Swinging gates have been used successfully to prevent fence damage by badgers (*Meles meles*) in pine plantations in the United Kingdom (Ratcliffe, 1974) and have been recommended for the prevention of fence damage by wombats in Australia (Breckwoldt 1983, Platt and Temby 1999, Triggs 2009). The recommended design of swinging gates made from lumber, however, may require regular maintenance (Breckwoldt 1983). Recently, heavy-duty steel wombat gates were designed to protect wallaby-proof fencing from wombat damage (Statham and Statham 2009). Not all property managers, however, readily accept the concept of swinging gates and allowing wombats to access their properties (Borchard and Collins 2001). Rather, they continue to focus on attempts to exclude them. Consequently, the success of wombat gates as a means of allowing wombats free access, while excluding unwanted predators from resources and crops, needs to be measured on 2 levels. At a practical level, the effectiveness of wombat gates remains to be rigorously tested, and their acceptance by property managers also needs to be evaluated.

The aim of this study was to test the effectiveness of 2 types of exclusion fencing and simple swinging gates in a field trial where several hundred metres of fencing had previously been erected to exclude wombats, wallabies, and foxes from a blueberry orchard. We hypothesised that because wombats feed mainly on grasses (Evans et al. 2006), we could allow them to access the blueberry orchard with no risk to the valuable blueberry resource. We, therefore, needed to construct a swinging gate that had the dual ability of providing managed passage to wombats while excluding wallabies and foxes. We also examined the patterns of behavior of all 3 species toward exclusion fencing and wombat gates by using motion sensing camera techniques developed in a recent study of wombats and cattle (Borchard and Wright 2010).

Methods

Study area

The study took place from August 2007 to June 2008 in a 22-ha blueberry (*Vaccinium corymbosum*) orchard situated 250 km south of Sydney (35°50'S, 150°21'E), Australia, in the Shoalhaven region of New South Wales. The orchard was bounded on 1 side by eastern riverine forest (Keith 2004) dominated by river oak (*Casuarina cunninghamiana*), river peppermint (*Eucalyptus elata*), black wattle (*Acacia mearnsii*), and water gum (*Tristaniopsis laurina*). Dry sclerophyll forest habitat contained white stringy bark (*Eucalyptus globoidea*), large fruited red mahogany (*E. scias*), grey ironbark (*E. paniculata*), rough-barked apple (*Angophora floribunda*), tick bush (*Kunzea ambigua*), hair pin banksia (*Banksia spinulosa*), and prickly shaggy pea (*Oxylobium ilicifolium*). This habitat surrounded the other 3 sides of the blueberry orchard. Introduced grasses such as kikuyu (*Pennisetum clandestinum*) and narrowleaf carpet grass (*Axonopus affinus*) occurred as a narrow buffer on the outside of the orchard and between the rows of blueberry shrubs within the orchard. Wombat burrows were broadly distributed across the surrounding landscape and occurred in high abundance on the surrounding stream banks (Borchard et al. 2008). The blueberry orchard was enclosed by a 2-m-high deer fence and was entirely covered by bird netting. When the study began, we recorded 17 wombat breaches of the existing deer fence around the farm; fourteen of these were located along the riparian interface.

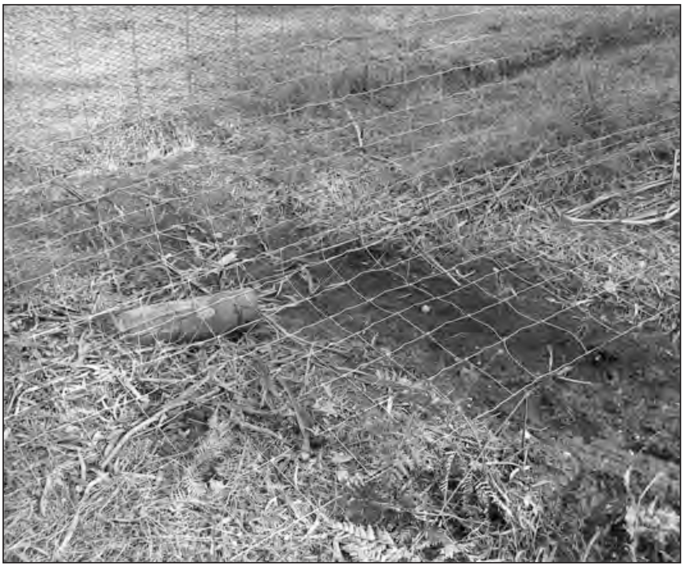

Figure 1. Wire mesh (hinge-joint wire) stretched flat across the ground and attached to the existing deer fence.

Several of these breaches appeared to be used more than other wildlife species, as identified by deep, hemispherical excavations of soil under the fence and the raised nature of the lower part of the netting (Marks et al. 1989, Marks 1998). Wombat breaches and subsequent damage to fencing had been repaired numerous times by the property owner.

Trial 1: exclusion fencing

We tested 2 types of exclusion fencing for excluding wombats, foxes, and wallabies. First, at the farm–riparian interface, we placed a 100-m-long section of foot-netting flat along the ground and secured it to the outside of the existing vertical deer fence (Figure 1). The foot netting was constructed of hinged-joint wire mesh (8 lines, 80 cm wide × 15-cm-spacings; Whites Wires Australia Pty., Ltd.). We attached hinged-joint wire to the existing fence at 1-m intervals using ring fasteners and secured it to the ground using tent pegs, also at 1-m intervals. We also secured patches of hinged-joint wire in the same manner on the inside of the existing fence at the 5 existing wombat breach points within this section. We patched each breach with hinged-joint wire on both sides of the existing fence as previously described. We tested the hinged-joint wire footing wire from August 29, 2007, to October 10, 2007. Our approach to flexible fencing was based on alternative materials used for excluding Tasmanian pademelons (*Thylogale billardierii*) from blackwood (*Acacia melanoxylon*) plantations in Tasmania (Jennings 2003). We secured a 100-m-long section of woven nylon material (0.8 m wide; Silt Fence, Rally Product, Australia) at a height of 30 cm to the existing fence at 30-cm intervals and secured outwards by 10 pegs along the riparian interface (Figure 2). The flexible fence spanned 5 existing wombat breach points that we also patched on the inside with hinge joint wire as previously described. We tested the flexible fence material from September 5, 2007, to September 26, 2007.

Trial 2: wombat gates

Following the testing of exclusion fencing (footing wire and flexible fence), we installed 6 swinging wombat gates at existing breach points within the exclusion fencing that either continued to be breached or were heavily impacted by breach attempts. We also installed

Figure 2. Flexible woven material (silt fence) attached to existing deer fence and secured to the ground using tent pegs.

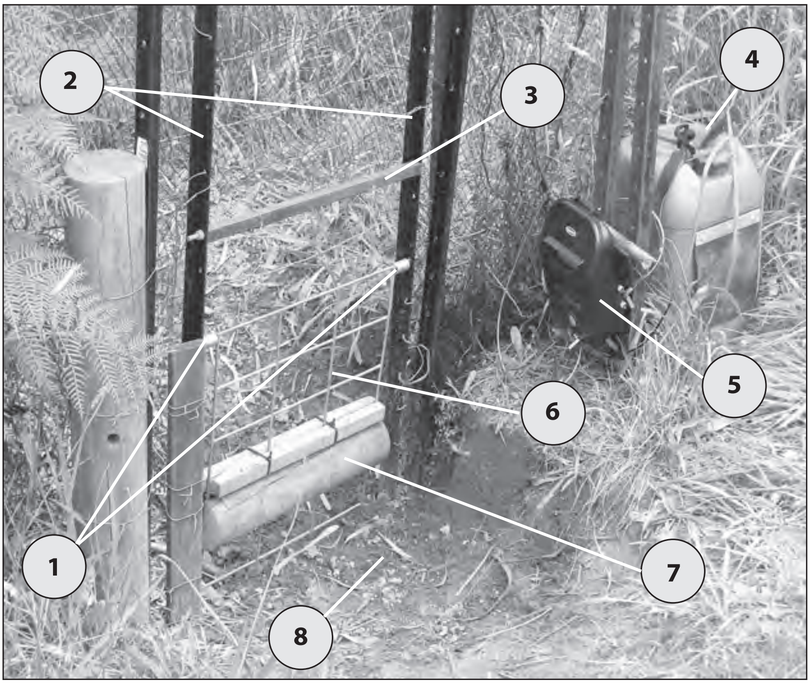

Figure 3: Installation of a swinging gate with parts described. (1) Bushings covering potruding tabs (pivot points) preventing gate from jamming on steel posts. (2) Steel posts rammed into earth. (3) Threaded rod within a steel tube to add strength to the structure. (4) Rechargeable battery in protective cover. (5) Moultrie camera. (6) Galvanized steel mesh ("weldmesh"), 200 x 100 x 5 mm. (7) Half-logs to add weight to gate to prevent acess of unwanted animals. (8) Hemispherical excavation caused by wombats scratching to access under original fence.

Figure 4. Wombat utilizing swinging gate.

another 2 wombat gates at other locations around the orchard, but we monitored frequency of use only at the riparian interface. Wombat gates were on average 0.6 m high × 0.5 m wide and constructed with 200 × 100 × 6 mm galvanized weldmesh steel material (Figure 3). When cutting out the gate from the larger sheet of steel mesh, we allowed the top run of wire to protrude approximately 50 mm on each side. These tabs formed the swinging pivot points. Installation of the gates required the excision of a section of deer fence above the hemispherical wombat excavation in the soil below the fence. We rammed 2 steel posts into the earth at each side of the hole, ensuring that the holes in the posts were aligned so that the 2

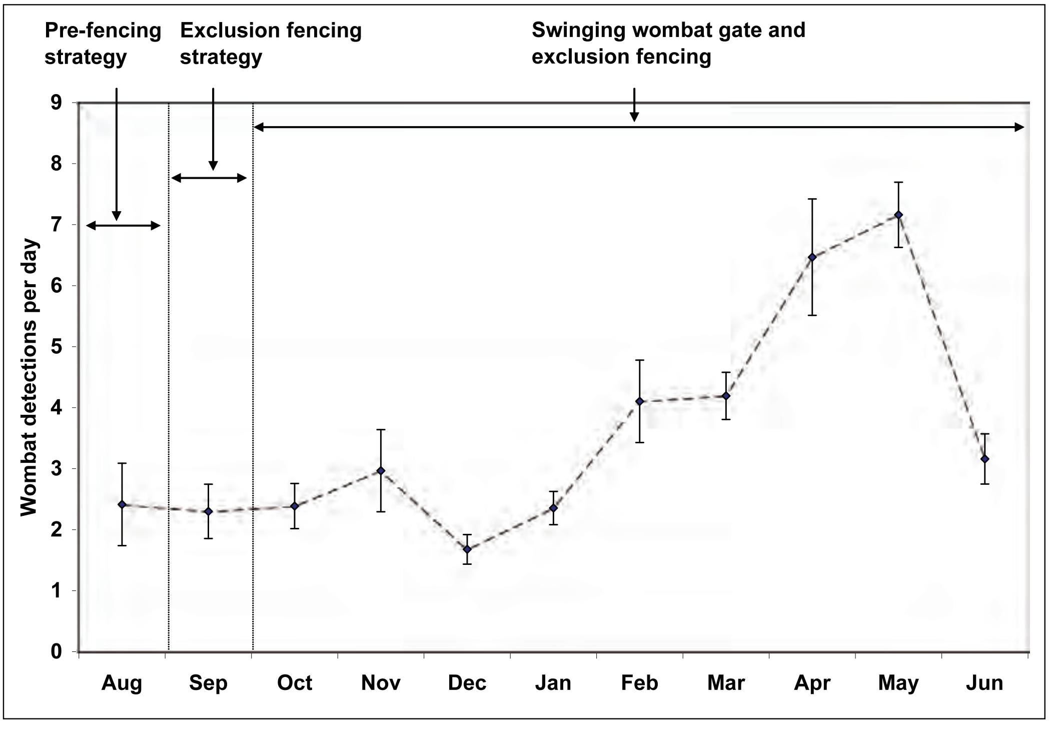

Figure 5. Mean (±SE) daily wombat detections, by month, recorded from August 2007 to June 2008 in a 10-month study of wombat activity in the vicinity of a blueberry orchard boundary fence. After pre-management monitoring, exclusion-fencing and swinging-gate techniques were tested.

protruding tabs could be inserted in the holes. We placed 2 cylindrical bushings over the tabs and pushed them tightly against the steel posts to prevent the gate from slipping to 1 side and jamming. We attached a threaded rod within a steel tube to both steel posts above the gate to form a strong, rigid frame that then could be secured to the surrounding deer wire. Finally, we attached 2 treated pine half-logs weighing about 2 kg to each side of the lower section of the gate. Wombats are strong enough to push the heavy gate open, whereas foxes and wallabies are not. We were careful to ensure that the swinging action of the gate followed the hemispherical shape of the existing excavation to avoid wombats scratching the soil under the gates.

Monitoring animal activity using camera traps

We continually observed the response of wombats and other animals to both the exclusion fencing and wombat gates using 4 Moultrie Game Spy I40 heat- and motion-sensing digital cameras (Moultrie Feeders, Alabaster, Ala., USA). The cameras were powered by 12-volt Panasonic rechargeable batteries. We secured cameras to permanently-positioned steel posts 30 cm above ground level and 1 m away from the wombat breach points (Figure 3). We positioned motion-triggered cameras at the 4 most heavily used breach points to test the exclusion fencing first and then the swinging gates. The cameras were approximately 50 m apart. We downloaded the images every 1 to 2 weeks. We set the cameras to capture 15-second videos, followed by a still image that recorded the time and date (Figure 4). We used a 1-minute image-delay between photos to avoid double-counting the same animal (Otani 2002, Bowkett et al. 2007). We used the number of animal detections to estimate the difficulty faced by an animal to breach an exclusion fence or gate; we use the term exclusion rate as a measure of effectiveness.

We compared detections of each species passing through the fence (or gate structure) with the numbers of that species detected in each 24-hour period, thus enabling calculation of exclusion rate for each species. Results were

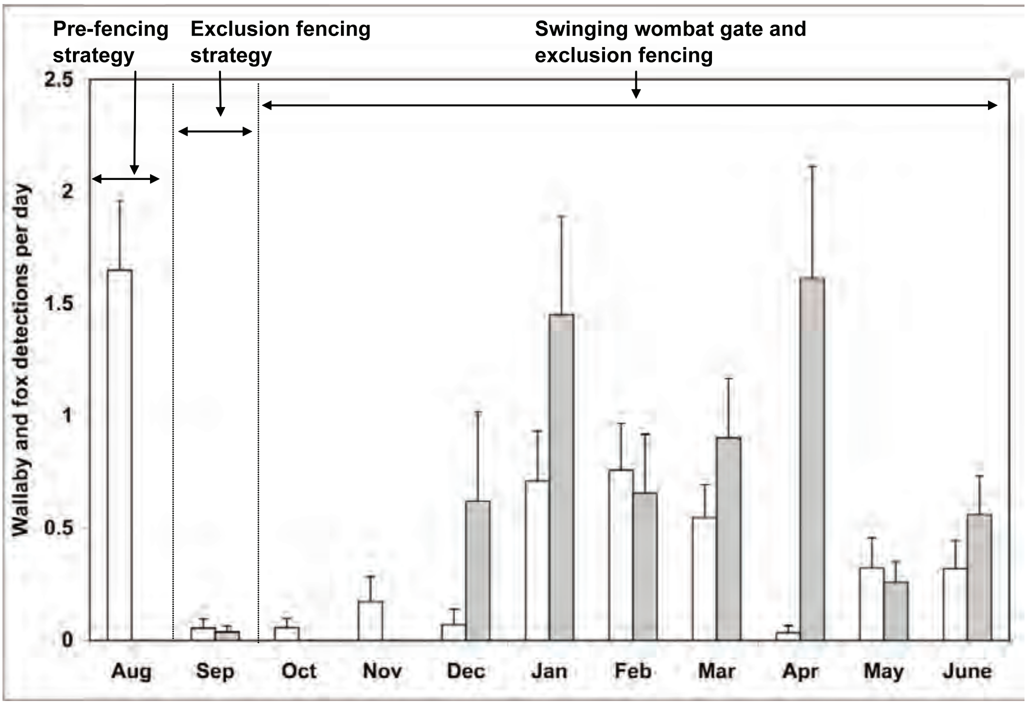

Figure 6. Mean (+SE) daily wallaby (shaded bars) and fox (unshaded bars) detections, recorded from August 2007 to June 2008 in a 10-month study of wombat activity in the vicinity of a blueberry orchard boundary fence. After premanagement monitoring, exclusion fencing and swinging-gate techniques were tested.

expressed as detections per day (24 hours). For example, we gave the fence a wombat-exclusion rate of 80% for 10 detections of a wombat and two were of a wombat breaching the fence in either direction over a single 24-hour period.

Results for each of the 3 target species (foxes, wallabies, and wombats) for daily detections were separately analysed using a 1-way analysis of variance (ANOVA) with time (by month) as the independent variable and number of detections as the dependant variable. The number of target species detected by camera within each 24-hour period, grouped by month, was the sample unit. All data were logarithmically transformed to approximate a normal distribution.

To test our hypothesis that exclusion fencing and swinging gates allowed wombats to successfully pass through the fence while excluding foxes and wallabies, we compared the exclusion rate of wombats compared to that of the target animals (foxes and wallabies combined), using Student's t-test. We compared daily exclusion rate for wombats to the combined daily exclusion rate of wallabies and foxes over different time periods relating to the existing fence, exclusion fence, and swinging gate combinations.

Results

We made 1,480 detections of the 3 target species between August 2007 and June 2008 (Figures 5 and 6). Most (79%) involved wombats; 12% were wallabies, and 8% were foxes. Wombat ($F_{10, 317} = 10.8$, $P < 0.0001$), wallaby ($F_{10, 317} = 4.81$, $P < 0.0001$), and fox ($F_{10, 317} = 6.93$, $P < 0.0001$) detections per day differed significantly by month (Figures 5 and 6).

Wombats were more successful at breaching fences than were foxes and wallabies ($t = 19.1$, df = 412, $P < 0.0001$). Over the entire 10-month study, an average of 79% of wombat detections were associated with successful exclusion fence breaches, or passage through swinging gates. In comparison, over the same period, only 15% of wallaby and fox detections (combined) were successful in breaching an exclusion fence or in using a swinging gate. Removing the period (August 2007) prior to exclusion fencing and wombat gates, the difference was even

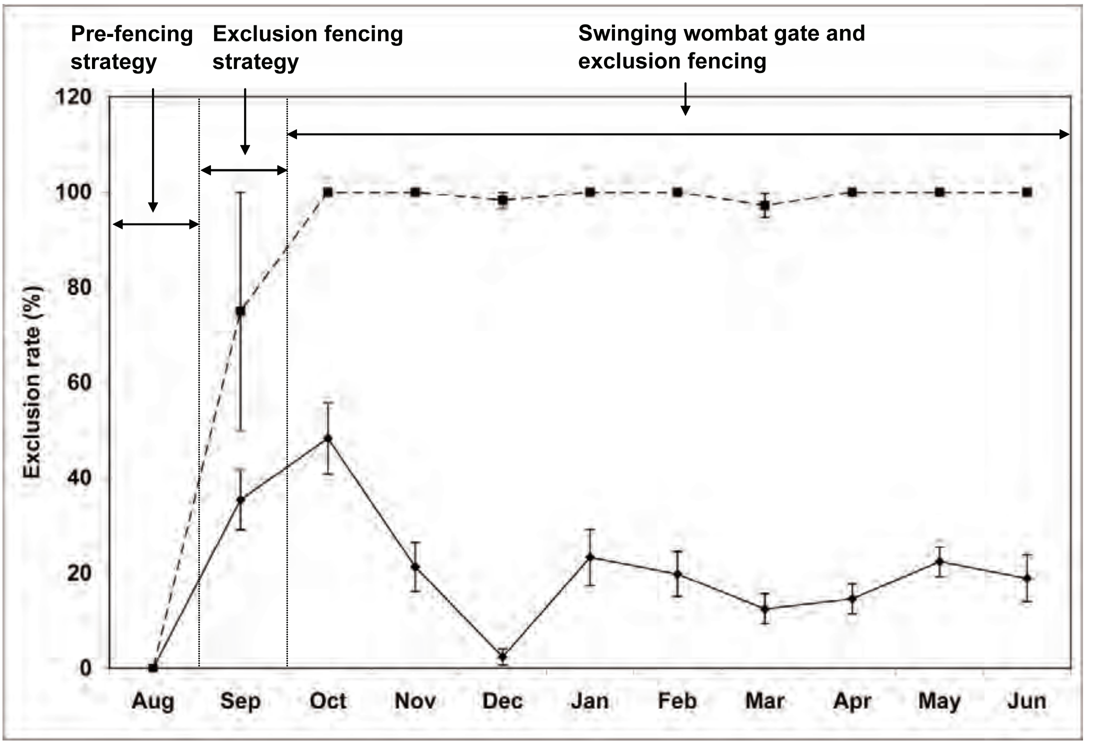

Figure 7. Mean (±SE) monthly exclusion rate for wombats (solid line) and wallabies and foxes (combined, dashed line) from August 2007 to June 2008 in a 10-month study of wombat activity in the vicinity of a blueberry orchard boundary fence. After premanagement monitoring, exclusion fencing and swinging-gate techniques were tested.

greater, with wombats still significantly more successful than foxes and wallabies ($t = 25.7$, df $= 381$, $P < 0.0001$). An average of 77% of wombat detections in the period September 2007 to June 2008 resulted in a successful breach of the fence. In comparison, only 2% of foxes and wombats were successful during the same period.

The pattern of successful travel through fences changed according to the 3 different fence treatments for the 3 species. The initial treatment was the *status quo* traditional fence, which had numerous preexisting holes from historic wombat activity. All detections of wombats and foxes were associated with fence breaches. We detected no wallabies in this period. This is expressed in Figure 7 as 0% fence exclusion rate for wombats, foxes, and wallabies. During September to October 2007, following the testing of exclusion fencing, which included footing wire and flexible fence, there were fewer fence breaches by wombats, wallabies, and foxes. The mean wombat exclusion rate was 35% for that period, and there was a higher wallaby and fox exclusion rate of 75% (Figure 7).

The second trial was the swinging-gate treatment. The first month of this treatment (i.e., October 2007) resulted in fewer successful fence breaches by wombats, with an average detection rate of 48% (Figure 7). Wombats became more successful at using the swinging gates over the next 3 months, with the exclusion rate dropping to 21%, 2%, and 23% from November 2007, December 2007, and January 2008, respectively (Figure 7). The exclusion rate remained <23% for the remaining 5 months of the trial.

There were no successful breaches by foxes and wallabies (100% exclusion rate) in the first month of the swinging gate trial (Figure 7). Similar levels of exclusion rates (i.e., between 97 and 100%) were sustained for the remaining 8 months of the swinging-gate trial.

Discussion

Our video data showed that wombats tried to breach a fence by biting and digging through the hinged-joint wire, but if they were able to find the leading edge of the exclusion wire, they quickly utilized the scratch-and-lift method to gain access. Although anecdotal evidence suggested that wombats are deterred by flexible material, our flexible-exclusion fencing was breached by wombats, which were able to chew through it with relative ease.

Once wombats breached the exclusion fence, wallabies and foxes were quick to take advantage of the newly-created opening; this explains the exclusion rate of 75% over 4 weeks. Video footage shows that foxes were able to contort their body shape to fit into the smallest of openings. Wallabies, on the other hand, appeared to require an opening large enough to fit their head through, relying on their relative pear-shape to further open up the hole on passage through the fence. In the absence of fence damage by wombats, however, the exclusion-fence design appeared to contain the elements for successful fox and wallaby exclusion.

The swinging-gate phase of our study showed a clear pattern of adaptation by wombats over the first month (i.e., October 2007), with an average detection rate of 48%. From January to June 2008, the number of wombat detections was reduced to an average of 25% as the gates led to easier passage and, therefore, less time spent within camera range. The swinging gates were consistent in excluding foxes and wallabies. On 1 occasion, however, video showed a wallaby rocking a gate with its forepaws while balancing on its hind legs. The wallaby gained access when the gate was swung far enough to squeeze its head under. We rectified this problem by increasing the weight of the gate to approximately 3 kg. On another occasion, a fox was able to gain access at a swinging gate when it was jammed open by a fallen branch. This highlights the need for constant monitoring and repair. Video footage showed variable patterns of wombat passage through the gate. Some wombats used a charging strategy to enter the gates. Other wombats pushed half way through the opening, paused, and balanced the gate either on their head or back before continuing through. This approach was particularly apparent where deep hemispherical excavations, which were made prior to gate installation, necessitated steep access and egress, thus, resulting in more challenging progression through the openings.

Conclusions

The results of this study showed that swinging wombat gates were more effective than exclusion fencing at selectively regulating access by wombats, wallabies, and foxes. However, both methods together probably contributed to managing wombats and other unwanted species on a whole-farm basis. Wombats can make numerous breaches in fencing and the installation of gates at every breach point may be impractical. Therefore, gates should always be installed at the most well-used breaches. Exclusion fencing, as described here over minor fence breaches, indicated by less fence damage and soil disturbance, should serve to condition wombats over time to use the gates by forcing them to utilize an easier access option provided by a swinging gate (Breckwoldt 1983). According to Triggs (2009), anecdotal evidence suggests that wombats will use gates placed up to 800 m apart without making new holes. The decision to use wombat gates alone or a combination of both wombat gates and exclusion fencing will depend on the extent of the problem, the cost of the damage, and the cost to purchase, erect, and maintain the length of fence protection required. The success of swinging gates in this study shows potential for this device to help alleviate wombat damage in rural Australia.

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