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Excluding livestock from farm dams enhances native biodiversity

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ABSTRACT

Amid a global biodiversity crisis and with over 50 % of the world's land dedicated to agriculture, solutions that enhance the biodiversity value of farmland are crucial. Fencing farm dams to prevent livestock access may provide numerous production and biodiversity benefits. However, we have limited information on the responses to fencing dams by various taxa, and its subsequent effect on community assemblages and ecosystem function. We investigated the impact of fencing farm dams on species richness, functional diversity, and community structure in a control-impact study in south-eastern Australia by comparing 20 fenced and 20 unfenced dams (40 dams total). We used a combination of in-person surveys, trail cameras, eDNA, and acoustic loggers to detect a wide range of fauna. We found significant differences in overall species richness, functional diversity and species composition between fenced and unfenced dams. Taxonomic groups including birds and mammals, and feeding guilds including carnivores and frugivores were more prevalent at dams that excluded livestock. Our results suggest that excluding livestock from farm dams preferentially benefits native species. At the species level, larger-bodied waterbirds such as dabbling ducks tended to prefer unfenced dams, while smaller woodland birds characteristic of nearby remnant woody native vegetation preferred fenced dams. We show that excluding livestock from farm dams has significant positive effects on biodiversity, ecosystem function and community structure.

1. Introduction

Agriculture dominates 50 % of the world's terrestrial environments (Ritchie and Roser, 2019) and agricultural land management practices are the largest contributor to biodiversity loss (Dudley and Alexander, 2017). Freshwater systems have high biodiversity value (Gibbs, 2000), yet have been heavily impacted by cropland conversion, with an estimated 21 % of inland wetlands lost globally since the start of the 18th century (Fluet-Chouinard et al., 2023). However, artificial farm dams, also known as farm ponds, are small water bodies that are ubiquitous in pastoral landscapes and can provide critical resources for various taxa (Brainwood and Burgin, 2009; Littlefair et al., 2024). In Australia alone, an estimated ~1.765 million dams have a combined surface area of ~4700 km^2 (Malerba et al., 2021). The widespread presence of farm dams within agricultural landscapes presents a unique opportunity to enhance biodiversity on a large scale. However, with a significant shortfall in global nature-based funding (Karolyi and la Puente, 2023), it is vital to identify cost-effective land management practices that increase the biodiversity value of farm dams and offset the loss of natural wetlands.

Domesticated ungulates, including cattle and sheep, can impact freshwater systems by reducing water quality and altering topography, soil structure, fire regimes, and vegetation communities and structure (Krall and Roni, 2023; Mihailou and Massaro, 2021; Rowland and Lovelock, 2024). Non-native ungulates directly impact native fauna through resource competition, physical disturbances such as trampling, and pathogen transmission (see Davis et al., 2016). Excluding domestic ungulates from aquatic habitats may ease these pressures and improve biodiversity outcomes. However, responses can depend on factors such as historical disturbance regimes, site productivity and landscape context (Lunt et al., 2007).

Various land management actions can offset livestock's negative impacts on aquatic habitats, including revegetation, de-stocking or rotational grazing, set-aside, and permanent exclusion (Díaz-Pereira

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et al., 2020; Teague and Kreuter, 2020). Exclusion through fencing may be particularly desirable because it is relatively inexpensive and avoids excluding large areas of land from agricultural production. For example, fencing farm dams has been linked to improvements in a range of water quality parameters (Evans et al., 2024; Malerba et al., 2022; Westgate et al., 2022), and improved water quality may, in turn, enhance livestock condition (Dobes et al., 2021; Lardner et al., 2005; Willms et al., 2002). Excluding livestock from farm dams has, directly or indirectly, been linked to improvements in amphibian abundance (Littlefair et al., 2025, Littlefair et al., 2024), bird species richness (Smith et al., 2024) and macroinvertebrate richness and abundance (Westgate et al., 2022). Moreover, livestock exclusion consistently leads to increases in

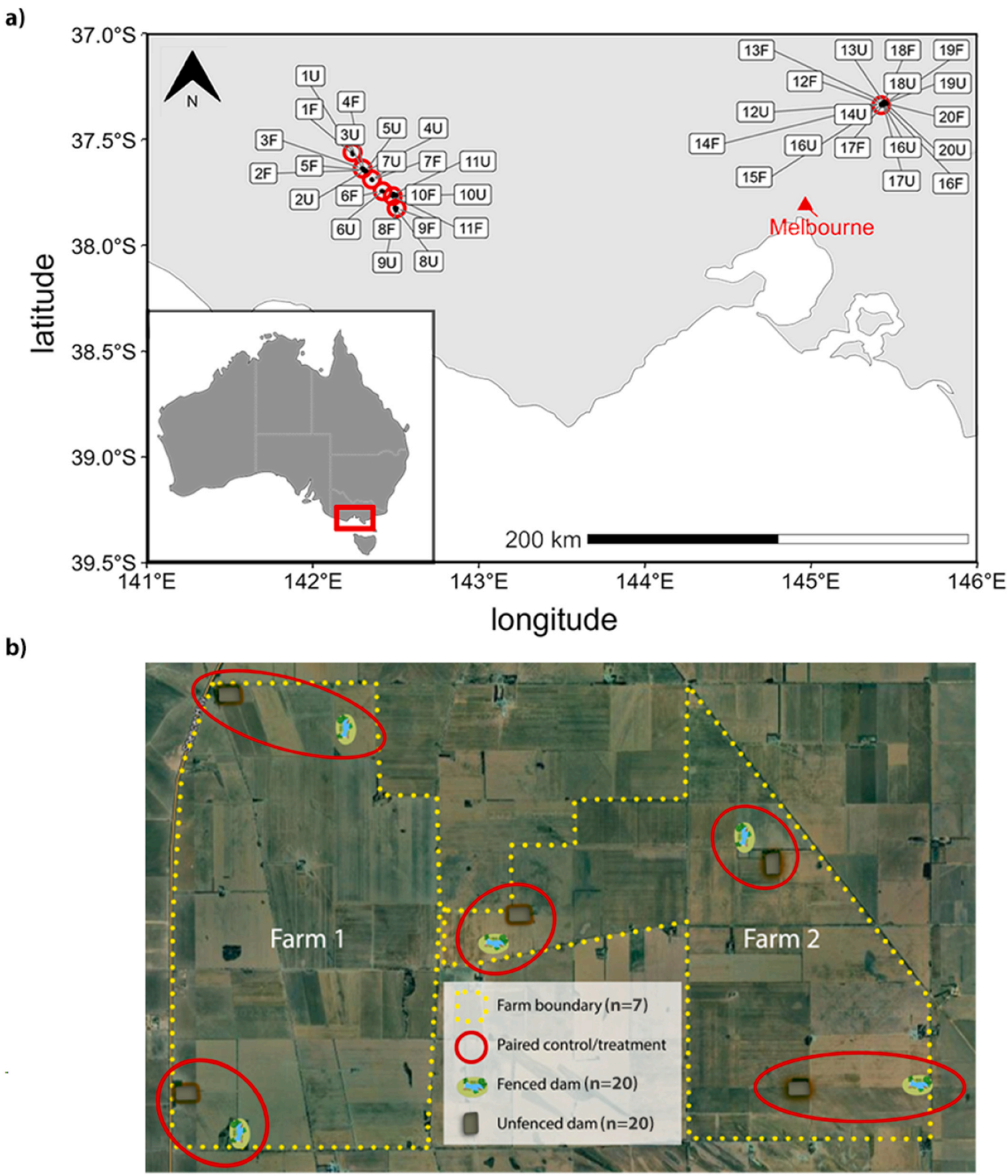

Fig. 1. Study properties (red circles; panel a), study dams (black dots and labels; panel a) and location within Victoria, Australia (inset; panel a). A simplified schematic of the landscape-scale study design, showing multiple pairs of fenced and unfenced dams distributed across seven farms (b).

the recruitment of woody vegetation (Spooner et al., 2002; Su et al., 2015). In addition, fencing farm dams can help mitigate climate change by significantly reducing methane emissions through improvements in nutrient levels and water quality (Malerba et al., 2022; Odebiri et al., 2024). Fencing farm dams may therefore have the potential to improve biodiversity and climate resilience.

Despite increasing interest in the biodiversity values of farm dams (Lewis-Phillips et al., 2019, 2020; Littlefair et al., 2024), studies investigating biodiversity responses after livestock exclusion are rare. Most existing work has focused on specific taxonomic groups, using in-person survey approaches for species detection (Littlefair et al., 2024; Smith et al., 2024). However, effective management of biodiversity requires understanding whole communities (Barraclough, 2015). In this study we evaluated the presence of all vertebrate and macroinvertebrate taxa across both the terrestrial and aquatic domains of farm dams using visual/aural surveys, active searching, acoustic loggers, trail cameras, and eDNA collection. This detailed, cross-taxa approach is uncommon (Buxton et al., 2018), and has not previously been applied in the context of farm dams. We used this monitoring approach to answer three key questions:

1. Do fenced dams support greater species richness than unfenced dams?
2. Do fenced dams have different species composition compared to unfenced dams?
3. Do fenced dams enhance the richness of functional guilds?

Our approach considers species interactions and ecosystem functions beyond taxonomic boundaries, providing deeper insights into community dynamics and the contributions of different organisms to observed differences.

2. Methods

2.1. Study area and design

We conducted our study at 20 paired treatment (fenced) and control (unfenced) sites, encompassing a total of 40 dams across seven grazing farms in southeastern Australia (Fig. 1). Livestock production on these farms involves cattle, sheep, or a combination of both. Fences were constructed using multiple horizontal and interlocking strands of wire, tensioned between and supported by evenly spaced wooden posts (Fig. 2). Although the construction of fences varied slightly between sites—with some incorporating barbed wire or electrification—all fences were designed to exclude livestock, while allowing passage for native mammals such as kangaroos, wallabies, and wombats. These fences did not prevent access by rabbits or other smaller animals. Treatment (fenced) dams had excluded livestock for at least two years before the surveys began.

Our study included human-made dams that rely on rainfall, surface runoff, and groundwater inflows to provide a permanent water supply for livestock. Fenced dams deliver water to livestock outside the fenced areas through various mechanisms, such as pumps or gravity-fed systems. Although these dams are designed to be permanent water sources, unpredictable weather patterns and prolonged droughts can impact the region, infrequently causing smaller or shallower dams to dry out, particularly late in the summer. Throughout the study period, all dams retained water. However, the smallest control dam ("Red") contained less than 10 cm of water by the end of the study.

Except for fencing to exclude livestock, the management practices between paired fenced and unfenced dams were comparable. No supplemental planting occurred on any dams, except for the introduction of native aquatic tubestock covering less than 5 % of the surface area in two fenced dams. Dams within sites were situated on the same farm, and we selected paired dams to be as close to one another as possible (average distance = 522.3 m, std. dev. = 453.6), of a similar size

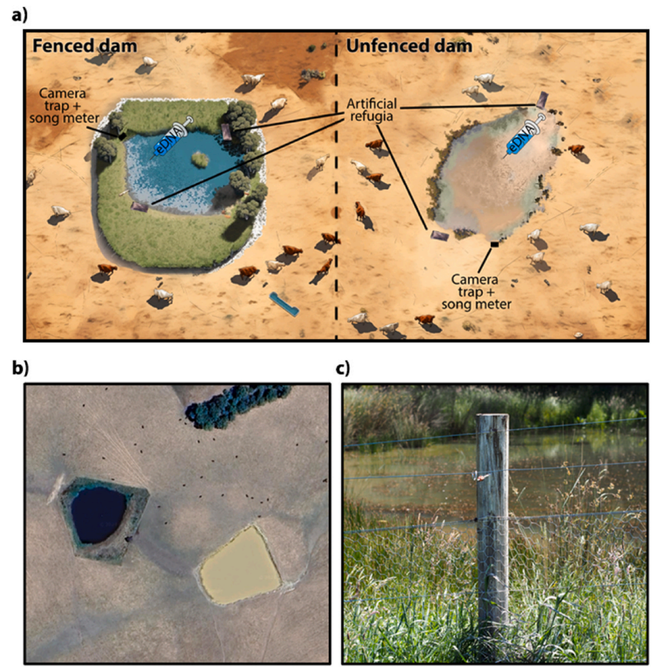

Fig. 2. An illustrative example of the dam-level study design, showing paired fenced and unfenced dams (left and right, respectively; panel a), with a typical arrangement of cameras, acoustic recorders, and artificial refugia. A satellite image of paired farm dams from the study (b), and an example of typical fencing used to exclude livestock, with a gap at the base to permit passage for small animals (c).

(average fenced = 1929 m^2, std. dev. = 1724; unfenced = 1316 m^2, std. dev. = 910), and similar depth (average fenced =1.62 m, std. dev. = 0.70; unfenced = 1.69 m, std. dev. = 0.75).

We conducted field surveys between October 2023 and January 2024, corresponding to the spring/summer season. We timed surveys to coincide with peak breeding activity for most species in the region during spring, the potential for greater reliance on farm dams during the dry summer season, the presence of summer migrant birds, and to minimise logistical constraints.

2.2. In-person surveys

We conducted in-person surveys three times during daylight hours (7 am – 6 pm), at the beginning (October 2023), middle (November/December 2023) and end (January 2024) of the 3.5-month project duration. Two observers used binoculars to survey the dams from the furthest distance that provided a clear view of the dam surface, recording species present in the area over a one-minute period. The distance of these surveys varied for each dam, influenced by factors such as aspect, visual obstructions, and the relative elevation of access tracks compared to the dam. Survey distances typically ranged from approximately 50 m to 300 m. Observers spent an additional two minutes documenting wildlife, either visually or aurally, while positioned on the dam wall. We included in surveys any species found within an estimated maximum radius of five meters beyond the dam wall, as well as across the interior area of the dam. We randomised the order of surveys at each site (paired fenced and unfenced dam) and the same principal investigator (KB) was present for all surveys. Following the timed surveys, we conducted a line transect survey by walking the entire circumference of each dam between the crest and the waterline, systematically recording all observed species. The duration of these surveys varied depending on dam size but typically lasted about 10 minutes. We checked for fauna under natural refugia such as logs and rocks, as well as temporary artificial refugia placed systematically for the purpose of this study

(Fig. 2). Artificial refugia included two stacked corrugated tin sheets and two concrete roof tiles set out at opposite ends of each dam.

2.3. Remote surveys

Immediately following the in-person surveys, we deployed AudioMoth acoustic loggers at each dam. We set loggers to record audio for one hour at dawn and one hour at dusk each day. The duration of audio recording at each dam ranged from ~43 hours to ~179 hours. We subsequently standardised recording time within sites to account for differing survey effort due to damaged or malfunctioning equipment. Following standardisation, we used AI software to detect the presence of birds and amphibians, and manually validated 17,205 individual detections to verify the precision of results and minimise false positives (see Supplementary Material: AI detection). We collected water samples from which to extract eDNA at each dam, and used general vertebrate and invertebrate primers to detect species presence (see Supplementary Material: eDNA). Finally, we deployed trail cameras at a single site (one fenced dam, one unfenced dam) within each farm to quantify livestock access, as well as detect secretive or nocturnal species that may be under-represented using other survey techniques. Cameras were active for the full 3.5-month duration of the project, with recording times subsequently standardized within paired sites to account for any unplanned disruptions.

Following amalgamation of all detections, we removed duplicate records where the same species was recorded multiple times at a single dam to avoid double counting the same individuals across different survey methods. We only considered species presence at each dam, to ensure consistency across survey methods, and because ecoacoustics and eDNA do not currently provide reliable abundance estimates. We then classified the observed species into a range of non-exclusive functional and taxonomic classes (see Fig. 3). Functional guilds included carnivores, decomposers, detritivores, frugivores, granivores, herbivores, pollinators, predators, and scavengers. We included both predators and scavengers, as well as all carnivores, as they perform distinct ecological roles, and low correlations (<0.6) allowed for simultaneous modelling, maximizing our chances of detecting differences. We also classified all detected species as either native or non-native to Australia and included this classification as a response variable (see 2.4 Statistical analysis). However, all other analyses grouped species regardless of their origin. Ecological information for birds was based on Garnett et al. (2015), while information for other taxa was collated manually using online searches and prior knowledge.

Detection errors are ubiquitous in ecological surveys, regardless of the method employed (Elphick, 2008). We acknowledge that detection errors may have occurred, particularly in our use of AI to automatically

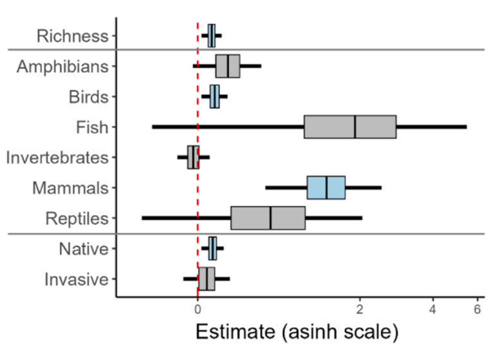

Fig. 3. Box plots of the effect estimates for different taxa in response to the presence of fencing around dams. The dashed red vertical line at zero indicates no effect. Positive parameter estimates indicate a positive association with fenced dams. Parameters whose credible intervals did not overlap zero are blue. The boxes represent the interquartile range (IQR) of the estimates, with the median as a central line, while the whiskers denote the 95 % credible intervals.

detect species from acoustic recordings. However, we manually assessed 100 % of species calls where the total number of detections for that species was less than 200. We used the same equipment and protocols across both fenced and unfenced dams, ensuring that any errors would be comparable between the treatment and control groups. Our comprehensive validation, use of multiple detection methods and study design give us confidence that errors were minimized and unlikely to significantly affect the results presented.

2.4. Statistical analysis

We tested differences in both species and guild richness between fenced and unfenced dams using a multivariate Bayesian regression model. We selected a multivariate Bayesian model to address the non-exclusivity of grouping factors (*e.g.*, species belonging to multiple functional groups), to reduce the risk of Type I errors, and to enhance estimation efficiency. The predictor variable was dam type (fenced vs unfenced) and we used different combinations of response variables to address our objectives.

For Question 1, we grouped species counts into broad taxonomic categories, including amphibians, birds, fish, invertebrates, mammals and reptiles, and also combined all taxa to calculate overall species richness. For Question 3, our response variables were intra-species counts within functional guilds, including carnivores, decomposers, detritivores, frugivores, granivores, herbivores, pollinators, predators, and scavengers.

We assumed a Poisson error distribution for all response variables, which represented grouped species counts at each dam. We initially modelled body mass and lifespan as response variables using a Gaussian error distribution. Subsequently, we log-transformed the variables and applied a Student's t error distribution to explore whether this approach would improve model fit. However, the model had poor fit, including divergent transitions, and Leave One Out (LOO) cross-validation (Vehtari et al., 2017) indicated a better fit without these variables, so we excluded them from the final model. We included a random intercept effect of farm dam nested within a site (paired treatment/control dam), with each site subsequently nested within the farm where they were located. This nested random effect structure helped account for variations across sites and farms, reducing the likelihood that observed effects are confounded by differences in location or farm-level characteristics. We used weakly informative priors for the fixed and random effects, and ran the model with four chains, each consisting of 20,000 iterations, with a burn-in of 1000 iterations and no thinning. All Rhat values were below 1.01, suggesting that the chains converged properly. We performed posterior predictive checks and the bulk and tail effective sample sizes (ESS) for all parameters exceeded 5000, indicating sufficient sampling and good fit between the observed data and the model predictions.

For Question 2, we tested for differences in species composition between treatments and controls using a Permutational Analysis of Variance. We specified the Bray–Curtis dissimilarity matrix as the response variable and dam type (fenced or unfenced) as the treatment variable. We set alpha at 0.05 and calculated multivariate *p*-values using 1000 residual resamples. We visualised community data using non-metric multidimensional scaling (NMDS) with Bray-Curtis dissimilarities.

We performed the analyses in R version 4.3.1 (Core Team., 2023), using the 'brms' package (Bürkner, 2017) for the Bayesian multivariate regression modelling, the 'adonis', 'metaNMDS' and 'simper' functions from the 'vegan' package (Oksanen et al., 2022) for the community dissimilarity analysis, and 'ggplot2' for visualisation (Wickham, 2016).

3. Results

3.1. Do fenced dams support greater species richness than unfenced dams?

We recorded 217,360 detections of animals over the survey period, comprising 218 individual species across all study sites (Table 1). Species richness was significantly higher at fenced dams, with a total of 185 species detected compared to 155 species at unfenced dams. Species richness was highest for birds (114 species), followed by invertebrates (70), and mammals (16). All taxonomic groups examined were at least as likely to be detected at fenced dams compared to unfenced dams (Fig. 3). Birds and mammals were significantly more prevalent in fenced dams. That is, members of these groups were present more often at fenced dams compared to unfenced dams, after accounting for differences between sites and farms. These differences across taxonomic groups were driven by native species, which responded positively to fenced dams, while non-native species showed no significant variation between dam types.

3.2. Do fenced dams have different species composition compared to unfenced dams?

We found a significant difference in species composition between fenced and unfenced dams (PERMANOVA $F_{1,38} = 2.61$, $p = 0.002$: Fig. 4a). The majority (81.1 %) of species that contributed significantly to the difference in faunal communities were more prevalent at fenced dams (Supplementary Material: Table SM2), including superb fairywren (*Malurus cyaneus*; average prevalence: 65 % fenced vs 15 % unfenced), grey fantail (*Rhipidura albiscapa*; 85 % vs 45 %), Australasian grebe (*Tachybaptus novaehollandiae*; 55 % vs 25 %), and New Holland honeyeater (*Phylidonyris novaehollandiae*; 50 % vs 15 %; Fig. 4b). Conversely, masked lapwing (*Vanellus miles*; 45 % vs 80 %), a species of oligochaete worm (*Limnodrilus sp.*; 45 % vs 85 %), Australian wood duck (*Chenonetta jubata*; 60 % vs 90 %), and an earthworm (*Eukerria saltensis*; 5–40 %) contributed significantly to differences and were more prevalent at unfenced dams. Birds were the most common taxa encountered, with waterbirds including grey teal (*Anas gracilis*), shelducks (*Tadorna tadornoides*), pink-eared ducks (*Malacorhynchus membranaceus*), wood ducks and yellow-billed spoonbills (*Platalea flavipes*) more commonly encountered at unfenced dams. Smaller-bodied woodland birds including Horsfield's bronze-cuckoo (*Chrysococcyx basalis*), eastern yellow robin (*Eopsaltria australis*), thornbills (*Acanthiza nana* and *Acanthiza pusilla*), grey fantail, eastern spinebill (*Acanthorhynchus tenuirostris*) and mistletoebird (*Dicaeum hirundinaceum*) were all more prevalent at fenced dams. The growling grass frog (*Ranoidea raniformis*), a nationally-threatened amphibian species, was detected at 12 dams (7 fenced and 5 unfenced).

3.3. Do fenced dams enhance the richness of functional guilds?

As with taxonomic groups, all functional groups examined were at least as likely to be detected at fenced dams compared to unfenced dams. Carnivores, the sub-group predators, and frugivores, were significantly more prevalent at fenced dams (Fig. 5). There was some evidence that pollinators were more common in fenced dams, and decomposers were more common in unfenced dams (see credible intervals in Fig. 5 just overlapping zero). Bird species were the most commonly detected taxa of frugivores, granivores, pollinators, predators, and scavengers. Invertebrates were the most common decomposers and detritivores (Supplementary Material: Table SM1).

4. Discussion

4.1. Do fenced dams support greater species richness?

Biodiversity can enhance ecosystem resilience, provide essential ecosystem services, and contribute to economic, social and cultural values (Cardinale et al., 2012; Pascual et al., 2023). Improving the conservation value of agricultural landscapes is a global priority (Campbell et al., 2017). We found that excluding livestock from farm dams significantly increased species richness and the prevalence of native species, birds, and mammals. Our findings add to the growing evidence that fencing farm dams benefits various taxa and faunal assemblages (Brainwood and Burgin, 2009; Littlefair et al., 2024; Smith et al., 2024; Westgate et al., 2022). However, the mechanisms which underpin these effects remain poorly understood. It is likely that excluding livestock fosters vegetation regeneration, which subsequently enhances microhabitat complexity and niche differentiation. Previous work has found that combining restoration plantings with fenced farm dams can provide greater biodiversity gains than restoration plantings alone (Smith et al., 2024), suggesting an additive effect of vegetation close to dams. Testing the specific attributes of habitat structure and vegetation that promote increased species richness at fenced dams could enable more focused management strategies, further enhancing biodiversity while minimizing costs or inputs.

4.2. Do fenced dams have a different species composition?

We found significant differences in the community composition of fauna between fenced and unfenced dams. Most species contributing to differences were associated more with fenced dams, including all small woodland bird species such as robins, fairy-wrens, thornbills and honeyeaters. Given that temperate woodland was the predominant habitat type before land clearing in our study area (Lunt and Bennett, 2000), our results suggest that fenced dams now support faunal assemblages more closely aligned with those found in remnant native vegetation. While we did not assess nearby uncleared reference sites, similar convergence in bird assemblages with those found in native remnant vegetation has been observed in revegetated farmland close to our study region (Haslem et al., 2024). Prolonged exposure to livestock grazing can alter ecosystem function and prevent the recovery of temperate woodlands, even following removal of the degrading process (Prober et al., 2017). Our results suggest that fencing farm dams can achieve positive biodiversity outcomes, even on long-cleared farmland.

Fenced farm dams may also provide resources for non-native vertebrate species. Black rats, foxes, wild pigs, rabbits, hares, and deer were all more prevalent in fenced dams, although differences in detections

Table 1
Summary of detections and species richness by taxonomic groups between fenced and unfenced dams.

	Detections			Species richness		
	Unfenced	Fenced	All	Unfenced	Fenced	All
Amphibians	31,337	111,370	142,707	7	9	9
Birds	32,760	41,185	73,945	84	100	114
Fish	1	5	6	1	3	3
Invertebrates	304	276	580	48	53	70
Mammals	43	62	105	10	16	16
Reptiles	9	8	17	5	4	6
TOTAL	64,454	152,906	217,360	155	185	218

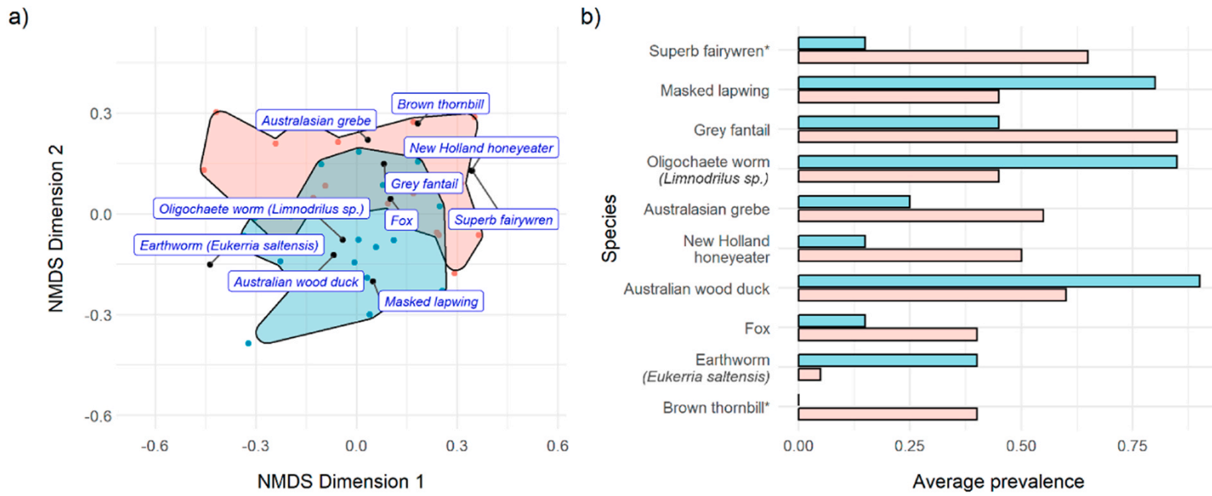

Fig. 4. Species community composition between sites (a) and average species prevalence (b) between fenced (red) and unfenced (blue) farm dams. The positions of the ten species that contributed most to the dissimilarity are reported in the panel. Species in (b) are provided from top to bottom in order of their contribution to average between-group dissimilarity. All listed species were significant ($p < 0.05$), with species significant at $p < 0.01$ denoted by the suffix "* ".

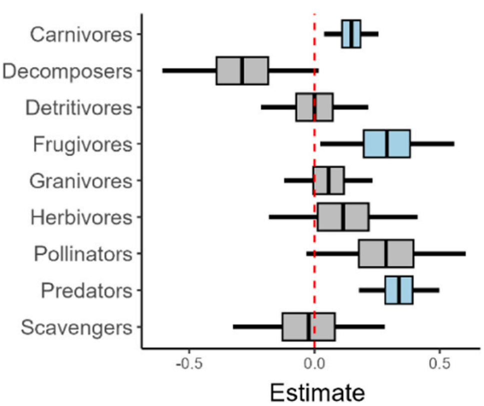

Fig. 5. Box plots of the effect estimates (with 95 % credible intervals) for different ecological functions in response to the presence of fencing around dams. Positive parameter estimates indicate a positive association to fenced dams. Parameters whose credible intervals did not overlap zero are blue. The boxes represent the interquartile range (IQR) of the estimates, with the median as a central line, while the whiskers denote the 95 % credible intervals.

were significant only for rats and foxes, and there was no strong aggregate signal of invasive species from our statistical tests. Alien meso-predators have been negatively linked to nesting diving duck abundance (Holopainen et al., 2024), and predatory interactions may explain the reduced prevalence of many waterbird species in fenced dams, where foxes were more commonly detected. Invasive species are a significant and costly threat to native biodiversity in Australia (Stobo-Wilson et al., 2022; Woinarski et al., 2019) and worldwide (Clavero et al., 2009; Doherty et al., 2016; Mollot et al., 2017). Our results suggest that excluding livestock from farm dams preferentially benefits native species. Combining livestock exclusion and invasive species control may offer synergistic benefits for native biodiversity. To test this hypothesis, further research could explore the connections between farm dams, invasive species, and conservation values (Littlefair et al., 2024).

4.3. Do fenced dams enhance the richness of functional guilds?

We found that excluding livestock from farm dams significantly increased the prevalence of carnivores, frugivores, and predators. Conversely, we found weak evidence that decomposers preferred unfenced dams. The lower prevalence of vertebrates and predators at unfenced dams, along with a potential preference of soil-borne invertebrates, may indicate a reduction in top-down control. A reduction in top-down forcing can cause cascading effects on disease, carbon sequestration, and invasive species (Estes et al., 2011). Similarly, frugivores were more prevalent in fenced dams, and frugivory can be important for seed dispersal, creating a 'mobile link' facilitating habitat connectivity, plant diversity, and forest regeneration (García and Martínez, 2012; Lundberg and Moberg, 2003). Pollinators play a crucial role in supporting food security, biodiversity and ecosystem health and function (Potts et al., 2016). Though credible intervals narrowly overlapped zero, we found weak evidence that pollinators were also more prevalent at fenced dams. The increased prevalence of diverse ecological functions at fenced dams aligns with our earlier findings of higher species richness, though species richness does not always equate to enhanced functional richness (Lindenmayer et al., 2015). Our findings suggest that the species community at fenced dams enhances traits that are less prevalent at unfenced dams, highlighting the potential benefits of effective dam management to ecosystem processes.

4.4. Limitations

We detected differences between fenced and unfenced dams across a diverse range of biodiversity measures despite several considerations that may have obscured ecological patterns. First, the paired nature of treatment and control dams within a site meant many of the dams were situated close to each other, with the closest pair only ~20 m apart. As such, our ability to detect differences in mobile species that function at a landscape scale, such as birds and many pollinators (Shapira et al., 2024), was likely reduced. It is also possible that, for the closest dams, our acoustic recording devices detected distant species at the adjacent paired site. Nevertheless, we detected significant differences in the prevalence of seven bird species. While we could not quantify the potential importance of spillover effects from fenced dams to adjacent unfenced dams, future studies could include an additional, more isolated unfenced dam to help quantify these effects.

Second, the distinction between treatment (fenced) and control (unfenced) dams was less defined than we intended, with livestock detected within fenced dams on trail cameras at two out of five farms. However, in all instances the incursions involved only one or two animals for a limited amount of time. Third, some of the dams in our study were situated on farms characterised by relatively low-intensity, rotational grazing systems with low stocking densities. Biodiversity losses generally increase with agricultural intensification (Newbold et al., 2015; Tilman et al., 2002; Tscharntke et al., 2005), and less intense land management practices may have reduced the differences in biodiversity between unfenced and fenced dams (Evans et al., 2024). We used presence-only data, which does not give a representation of the abundances of species. Future refinements in eDNA and ecoacoustic analyses may allow for reliable estimates of abundance, thereby improving the power of statistical models. Despite these considerations, we still detected important differences in numerous species, including species which contribute important ecosystem services, suggesting our use of a wide range of survey methods for multiple taxa was effective. AI-assisted acoustic detections and eDNA monitoring continue to grow in popularity, power and reliability, offering non-invasive and efficient methods for detecting a wide range of species (Bruce et al., 2021; Pascher et al., 2022; Sharma et al., 2023). Our findings support the use of these passive monitoring methods as powerful supplementary techniques to in-person surveys.

We acknowledge that species counts are subject to various sources of error (Elphick, 2008), and our study may have been affected by reduced detectability of animals, particularly in the structurally complex habitats often associated with fenced dams. Notably, our species accumulation curves do not reach an asymptote (Supplementary Material: Figure SM1), suggesting that further sampling would likely reveal additional species. Improved detectability might have amplified some of the weak positive signals we observed (e.g., for amphibians and pollinators), further highlighting the biodiversity benefits of fencing farm dams.

Finally, our study focused on farm dams within a single environmental zone in one country over one season. Research on the effects of fencing farm dams is limited globally (Littlefair et al., 2024), with most studies conducted in North America and Australia. While we have no reason to believe that similar biodiversity benefits could not occur elsewhere, we recommend future studies assess broader spatial and temporal extents.

4.5. Conclusion and recommendations

Restoration of degraded woodlands requires reversing degrading processes, maintaining species diversity, improving community structure, and repairing ecosystem function (Yates and Hobbs, 1997). We found differences in functional and taxonomic biodiversity at dams where livestock have been excluded consistent with these goals, despite numerous factors reducing the power of our analysis. Dams that excluded livestock were preferred by higher-order consumers, and bird community composition at fenced dams more closely resembled that expected in remnant woodlands. We therefore recommend fencing farm dams wherever feasible to enhance biodiversity. Despite clear overall higher levels of biodiversity at fenced dams, unfenced dams remain valuable to a range of fauna. Indeed, the sole threatened species we detected, the growling grass frog, was found at a similar number of fenced (7) and unfenced (5) dams. The conservation of biodiversity does not have to be incompatible with food production goals (Zingg et al., 2024), and there is growing evidence that fencing farm dams can improve water quality (Evans et al., 2024; Odebiri et al., 2024) and offer potential livestock production benefits (Dobes et al., 2021). With an abundance of unfenced dams available globally, excluding livestock from farm dams could present a rare win-win scenario, benefiting both agricultural productivity and biodiversity.

5. Ethics

This research was conducted in accordance with the ethical standards of Deakin University and was approved by the Animal Ethics Committee Wildlife-Burwood (AECW-B) under permit number B16–2023.

6. Funding

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CRediT authorship contribution statement

Evans Maldwyn J: Writing – review & editing. **Bell Kristian:** Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Scheele Ben C:** Writing – review & editing. **Lindenmayer David B:** Writing – review & editing. **Malerba Martino E:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Conceptualization. **Smith David G:** Writing – review & editing.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Kristian Bell reports financial support was provided by BHP Group Ltd. Martino Malerba reports financial support was provided by Australian Research Council. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.agee.2025.109623.

Data availability

All data, code, and analyses will be made available following publication.

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