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Hospital admissions to Phillip Island Wildlife Clinic, Victoria, Australia, over a 10-year period, 2012–2021

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ABSTRACT

Wildlife clinics play a critical role in safeguarding the well-being and survival of diverse animal species, but their admissions data are also valuable for investigating threats and challenges impacting local wildlife. This study examines 10 years of admissions data from the Phillip Island Wildlife Clinic in Victoria, Australia, to identify species, primary causes, outcomes, and temporal trends of clinic admissions. Avian species constitute the majority of admissions (64.5%), with sea and water birds being the most frequently admitted group. Motor vehicle accidents, injuries of unknown cause, and orphaning are the dominant causes of admission for birds and mammals. Car strikes are the leading cause of admission for land birds, land mammals, macropods, and turtles. Orphaning exhibits a seasonal pattern, with a higher number of cases in spring. Overall, 59.1% of admissions resulted in mortality, with causes related to trauma showing significantly higher mortality risks than others. The findings emphasise the impact of tourism on wildlife populations and the urgent need for targeted conservation strategies on Phillip Island.

Keywords: admissions, Australian wildlife, conservation, endangered species, hospital admission, mortality, Phillip Island, wildlife.

Introduction

Wildlife clinics play a pivotal role in safeguarding the well-being and survival of rescued wildlife. By evaluating longitudinal admissions data from these facilities, a valuable opportunity arises to investigate the threats and challenges that impact the well-being of local species. This analysis not only enhances our understanding of these risks but also provides valuable insights to inform conservation strategies aimed at protecting and preserving wildlife, particularly vulnerable populations (Pyke and Szabo 2018).

Previous studies have provided valuable insights into wildlife clinic admissions and mortality rates across different regions of Australia. For instance, research conducted in south-east Queensland (SEQLD) revealed that marsupials accounted for the largest proportion of admissions (41.3%) (Taylor-Brown *et al.* 2019). The primary reasons for admission included car strikes (34.7%), orphaned young (24.6%), and overt signs of disease (9.7%) (Taylor-Brown *et al.* 2019). Studies in New South Wales (NSW) have also reported on wildlife clinic admissions, with avian species being the most commonly admitted taxa (Tribe and Brown 2000; Haering *et al.* 2021; Kwok *et al.* 2021). Similarly, a study investigating wildlife admissions to domestic animal veterinary clinics ($n = 132$) across Australia reported that birds were the most commonly admitted taxa (Orr and Tribe 2018). In agreement with Taylor-Brown *et al.* (2019), these studies also highlight car strikes as a leading cause of admission (Orr and Tribe 2018; Tribe and Brown 2000; Haering *et al.* 2021). Overall, the reported mortality rate across these studies is approximately 55% (Taylor-Brown *et al.* 2019; Tribe and Brown 2000; Haering *et al.* 2021; Kwok *et al.* 2021). However, mortality rates in sick and injured wildlife vary depending on the nature of the impact. For example, reported mortality rates in macropods from vehicle strike are much higher than 55%, at or approaching 90% (Taylor-Brown *et al.* 2019; Kwok *et al.* 2021).

Several studies have focused on individual species, such as the flying fox in Victoria (Scheelings 2015) and New South Wales (Mo *et al.* 2021), where entanglements have

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been identified as the primary cause of admission. Scheelings (2015) found a significant proportion of flying fox admissions were attributed to entanglements in fruit netting (36.8%), resulting in considerable mortality of up to 56.1%. For freshwater turtles in SEQLD, trauma, predominantly resulting from car strikes, emerged as the most common cause of admission (O'Leary *et al.* 2023). However, over the study period, an increasing number of turtles presented with disease (O'Leary *et al.* 2023).

Koalas have also received considerable attention in this area of research, particularly in NSW. Lunney *et al.* (2023) conducted an extensive examination of 18,039 koala admission records from NSW rehabilitation groups spanning 47 years. Their findings highlighted disease as a prevalent factor in koala admissions, accompanied by motor vehicle collisions, dog attacks, and instances of unsuitable environments. A parallel study conducted in Lismore (south-east NSW) over 31 years, exploring 5051 koala admissions, reaffirmed these results, emphasising the significant impact of disease, unsuitable environments, and dog attacks (Lunney *et al.* 2022). Furthermore, an additional analysis in Port Macquarie over a 30-year period identified motor vehicle collisions, dog attacks, and disease as notable contributors to koala admissions (Griffith *et al.* 2013). These findings align with studies conducted in other regions across Australia, which similarly highlight trauma (e.g. motor vehicle collisions, dog attack) and disease as common factors leading to koala admissions (Gonzalez-Astudillo *et al.* 2017; Charalambous and Narayan 2020). Together, these previous findings underscore the significant impact of human activities on a diverse range of wildlife, and the significant influence of disease. They also emphasise the urgent need for continued research and conservation efforts to protect Australia's iconic native species.

Located on a relatively small land area of 101 km^2, Phillip Island serves as a holiday destination for tourists. The island's popularity, however, increases the likelihood of human–wildlife interactions that can result in conflicts and incidents leading to animal injuries. To address these challenges, the Phillip Island Wildlife Clinic (PIWC; a registered wildlife shelter, utilising external registered veterinarians, both on and off-site) plays a crucial role in serving the wildlife population of the island. By thoroughly examining the nature and circumstances surrounding admissions at the clinic, this study has the potential to raise awareness among tourists and local communities, fostering a sense of responsibility and promoting wildlife conservation practices. Moreover, by gaining insights into these admissions, the study enables the development of informed strategies and interventions aimed at mitigating these risks and minimising their impact on the island's unique biodiversity.

Here I present the results of a 10-year analysis of data collected from the PIWC. The objectives of this study were to identify which species are being admitted to PIWC, in addition to the primary causes, outcomes, and temporal trends of clinic admissions to determine and quantify the current threats to their survival in this region.

Methods

Study site and data collection

The wildlife clinic admission records used in this study were obtained from the Phillip Island Wildlife Clinic (PIWC) (−38.470321°, 145.367326°) located in Phillip Island, Victoria, Australia. Phillip Island is situated 142 km south of Melbourne and encompasses an area of approximately 101 km^2; the last census (2021) recorded a population size of 13,799 (Australian Bureau of Statistics 2021). The clinic, established in 2011, forms part of Phillip Island Nature Parks, attracting approximately 2.7 million national and international visitors annually (Department of Jobs, Skills, Industry and Regions 2023).

Clinic admission records of 3842 wildlife patients admitted by members of the public to PIWC between 1 January 2012 and 30 December 2021 were compiled in an electronic database (Microsoft Excel, ver. 16.73) for organisation and analysis. Information contained in the records included: patient identification number, admission date, species, age category, cause of admission (COA), and outcome; although sex was included in the clinic records, data were not recorded consistently and were therefore not included in the analysis. Of the 3842 cases, 473 were excluded as follows: (a) non-native species, (b) incomplete records, and (c) species for which there were fewer than 50 individuals, unless they could be suitably pooled with species of another taxonomic, ecological or behavioural group. Given the significant number of species across taxonomic groups with fewer than 50 individuals, nine multispecies groups were formed based on taxonomic or ecological similarity. These groups encompassed sea and water birds, terrestrial birds, arboreal mammals, terrestrial mammals (excluding macropods), macropods, bats, turtles, and lizards.

These data were analysed for admission and outcome trends. Where trends were assessed per season, seasons were referred to as: summer (December, January, February), autumn (March, April, May), winter (June, July, August), and spring (September, October, November). COA, as determined by the attending veterinarian was used as a nominal outcome variable with 15 categories: 'caught accidentally' (e.g. chimney, building, drain, pool), 'caught in fishing line', 'unnecessary rescue' (i.e. animals were brought into the clinic by members of the public but were determined to be healthy by the veterinarian), 'unknown animal attack', 'dog attack', 'cat attack', 'disease', 'exhausted', 'orphaned', 'collision' (e.g. pole, wire fence, overhead wires, window), 'motor vehicle accident' (MVA), 'injury', 'paralysis', 'malnourished', and 'other' (causes of admission with fewer than 20 entries). Animal outcomes following admission were grouped into either 'positive

outcome' (released into wild or into care) or 'mortality' (dead on arrival, natural death, or euthanasia on welfare grounds). Phillip Island human population data were obtained from the Australian Bureau of Statistics (2021).

Statistical analysis

Statistical analysis was performed using 'R', ver. 2022.12.0 + 353 and Prism, ver. 9.5.1. Descriptive statistics were used to determine the frequency of cases for each season, diagnosis, and outcome during the study period. Linear regression was used to explore temporal trends, including total number of admissions and diagnoses. One-way ANOVA was performed to compare the average number of cases by season, utilising Tukey's *post hoc* analysis to explore pair-wise comparisons and investigate significant relationships. Finally, logistic regression was used to produce odds and risk ratios with 95% confidence intervals.

Results

Animal admissions

In total, 101 species were included in this study. Under the *Flora and Fauna Guarantee Act (1988)*, five species were listed as endangered (eastern barred bandicoot, *Perameles gunnii*; grey-headed albatross, *Thalassarche chrysostoma;* shy albatross, *Thalassarche cauta;* white-faced storm petrel, *Pelagodroma marina*; northern giant petrel, *Macronectes halli*), and three species were listed as vulnerable (grey-headed flying-fox, *Pteropus poliocephalus*; hooded plover, *Thinornis rubricollis*; common sandpiper, *Actitis hypoleucos*). Species were grouped by taxonomy, ecological niche or behavioural traits to assist analysis. In summary, species were grouped as sea and waterbirds (n = 41 species), terrestrial birds (n = 40 species), arboreal mammals (n = 3 species), land mammals (n = 4 species), macropods (n = 4 species), bats (n = 5 species), lizards (n = 2 species) and turtles (n = 2 species). A summary of admissions over the study period is presented in Table 1, Fig. 1.

The admissions to the PIWC were predominantly birds, which accounted for 64.5% (n = 2110/3269) of all admissions (Table 1). Among birds, sea and water birds comprised the largest multispecies group, with 38.3% (n = 1251) of total admissions, followed by terrestrial birds at 26.3% (n = 859). The three most frequently admitted sea and water bird species were the short-tail shearwater (*Puffinus tenuirostris*), Cape Barren goose (*Cereopsis novaehollandiae*), and purple swamphen (*Porphyrio porphyrio*), which together constituted 62.8% of waterbird admissions (n = 397, 237, and 152, respectively). The remaining 37.2% (n = 405) of sea and water bird admissions were attributed to 38 other species. As for terrestrial birds, the Australian magpie (*Gymnorhina tibicen*), rainbow lorikeet (*Trichoglossus moluccanus*), and galah (*Eolophus roseicapilla*) were the top three commonly admitted species, accounting for 42.6% of terrestrial bird admissions (n = 176, 99, and 91, respectively). The remaining 57.4% (n = 493) of terrestrial bird admissions were distributed across 37 other species.

Mammals represented the second most admitted animal group, comprising 32.6% (n = 1066/3269) of all admissions (Table 1). The most frequently admitted mammalian multispecies group consisted of arboreal mammals, accounting for 16.6% (n = 543) of all admissions, followed by macropods (13.5%, n = 442), land mammals (1.6%, n = 53), and bats (0.85%, n = 28). Brushtail possums (*Trichosurus vulpecula*; n = 275) and ringtail possums (*Pseudocheirus peregrinus*; n = 262) were the predominant arboreal mammals, making up 98.9% of this group. The remaining 1.1% (n = 6) of arboreal mammal admissions were attributed to koalas (*Phascolarctos cinereus*). Among the macropods, swamp wallabies (*Wallabia bicolor*) constituted most admissions (n = 429, 97.1%). The

Table 1. Summary of admissions to Phillip Island Wildlife Clinic from 2012 to 2021. Bold text indicates totals and primary causes of admission per group.

Animal group	Species	Number of admissions	% of total admissions	% positive outcome	Mortality	Top three causes of admission
Birds	Sea and water birds	1251	38.3	37.4	62.6	Injury unknown cause, MVA, orphaned
	Terrestrial birds	859	26.3	22.9	77.1	MVA, injury unknown cause, malnourished
		2110	**64.5**	**30.1**	**69.9**	**MVA, injury unknown cause, orphaned**
Mammals	Arboreal mammals	543	16.6	29.7	70.3	Orphaned, MVA, injury unknown cause
	Macropods	442	13.5	13.3	86.7	MVA, orphan, injury unknown cause
	Land mammals	53	1.6	56.6	43.4	MVA, caught accidentally, injury unknown cause
	Bats	28	0.9	64.3	35.7	Caught accidentally, unnecessary rescue, injury unknown cause
		1066	**32.6**	**44.1**	**59.0**	**MVA, caught accidentally, injury unknown cause**
Reptiles	Lizards	65	2	27.7	72.3	Injury unknown cause, dog attack, MVA
	Turtles	28	0.9	75	25	MVA, unnecessary rescue, injury unknown cause
		93	**2.9**	**51.4**	**48.6**	Injury unknown cause, MVA, dog attack
	Total animals	***3269***		***40.9***	***59.1***	***MVA, injury unknown cause, orphaned***

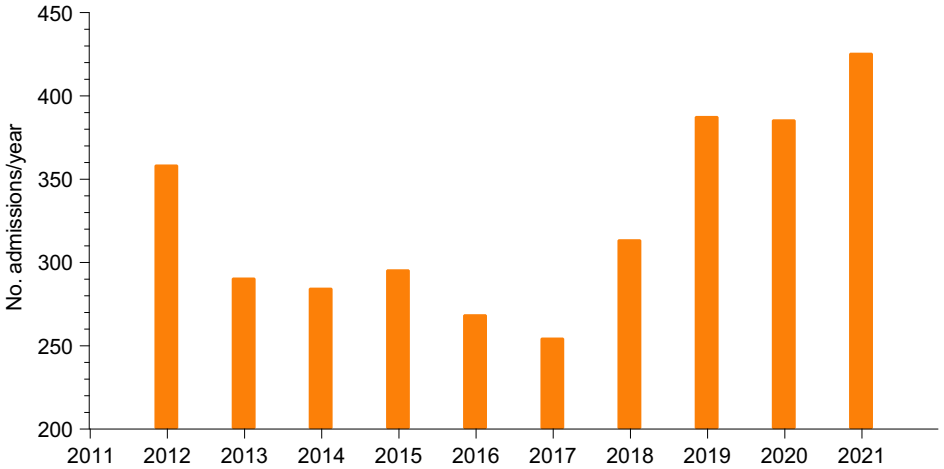

Fig. 1. Number of wildlife admissions per year.

remaining 2.9% were attributed to red-necked wallabies (*Macropus rufogriseus*; $n = 9$), eastern grey kangaroos (*Macropus giganteus*; $n = 3$), and a single tammar wallaby (*Macropus eugenii*). Echidnas (*Tachyglossus aculeatus*) were the most commonly admitted land mammals ($n = 41$), comprising 77.7% of this group. The remaining 22.3% of land mammal admissions included 12 eastern barred bandicoots (*P. gunnii*) admitted for 'injury unknown cause' ($n = 7$), 'caught accidentally' ($n = 2$), 'orphaned' ($n = 2$), and MVA ($n = 1$). The most frequently admitted bat species were the wattled bat (*Chalinolobus gouldii;* $n = 12$), the lesser long-eared bat (*Nyctophilus geoffroyi*; $n = 8$), and the chocolate wattled bat (*Chalinolobus morio*; $n = 6$), constituting 92.9% of this group. Lizards and turtles accounted for 2% ($n = 65$) and 0.86% ($n = 28$) of all admissions, respectively. The lizard multispecies group consisted of blue-tongued lizards (*Tiliqua scincoides scincoides;* $n = 64$) and a single stumpy-tailed lizard (*Tiliqua rugosa*). The turtle multispecies group comprised 27 long-necked tortoises (*Chelodina longicollis*) and a single green turtle (*Chelonia mydas*).

Over the 10-year study period, there was a 19% increase in the total number of admissions (from 359 in 2011 to 426 in 2021), concomitant with an increase in human population size (Fig. 2). However, the total number of animals admitted per year did not show a significant change ($F_{1,8} = 3.892$, $P = 0.084$). The average annual admission rate was 326.9 animals per year (s.e.m. ± 18.7). Notably, the annual admissions of terrestrial birds, arboreal mammals, and macropods showed a significant increase over the study period (terrestrial birds, $F_{1,8} = 7.685$, $P < 0.05$; arboreal mammals, $F_{1,8} = 12.89$,

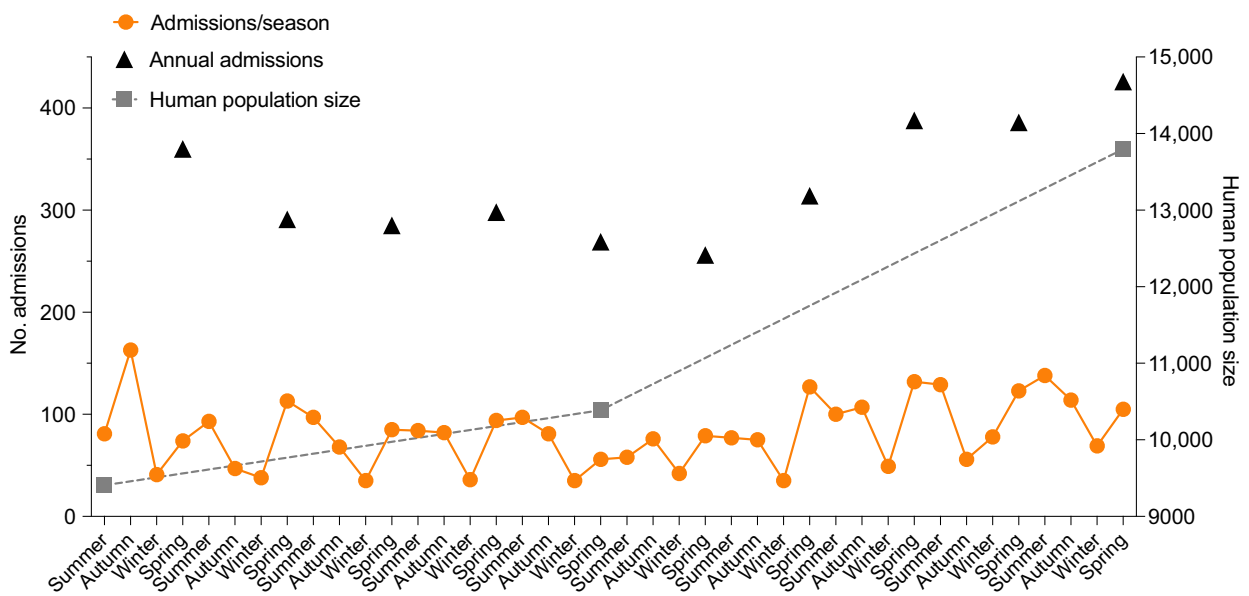

Fig. 2. Total admissions per year and month (left axis) and human population size (right axis) during the study period.

$P < 0.01$; macropods, $F_{1,8} = 15.07$, $P < 0.01$). Conversely, there was a significant decline in the annual admissions of lizards ($F_{1,8} = 6.302$, $P < 0.05$).

Causes of admission

Overall, the most common COA was 'MVA', accounting for 837 admissions (25.6%), followed by 'injury unknown cause' (n = 829; 25.3%), 'orphaned' (n = 529; 16.2%), 'malnourished (n = 297; 9.1%), 'caught accidentally' (n = 177; 5.4%), and 'unnecessary rescue' (n = 149, 4.6%). These six causes together constituted 86.2% of all clinic admissions (2818/3269).

'MVA' was the leading cause of admission for four of the eight multispecies groups (Table 1). Terrestrial birds were the most commonly admitted group for 'MVA' (n = 293/837, 35%), followed by macropods (n = 231/837, 27.9%) and waterbirds (n = 189/837, 22.6%) (Table 2). The second-highest admission category was 'injury unknown cause', which affected all multispecies groups. Sea and water birds (n = 393/829, 47.4%), terrestrial birds (n = 267/829, 32.2%), and arboreal mammals (n = 70/829, 8.4%) were most frequently admitted in this category. 'Orphaned' was the third-highest cause of admission overall, accounting for high proportions of arboreal mammal (n = 219/529, 41.4%), sea and water bird (n = 186/529, 35.2%), and macropod (n = 67/529, 12.7%) admissions. 'Malnourished' was the fourth most common cause of admission (9.1% of all admissions). Water birds made up the largest proportion of this category (n = 170/297, 57.2%), followed by terrestrial birds (n = 55/297, 18.5%) and arboreal mammals (n = 48/297, 16.1%). 'Caught accidentally' (e.g. chimney, building, drain, pool) was the fifth most common cause of admission, with water birds accounting for 39% of all these admissions. Arboreal mammals (n = 36/177, 20.3%) and macropods accounted for 20.3% (n = 36/177) and 15.8% (n = 28/177), respectively. 'Unnecessary rescue' was the sixth cause of admission, with sea and water birds and terrestrial birds accounting for 65.8% (n = 98/149) and 16.8% (n = 25/149) of these admissions, respectively.

Table 2. Leading causes of wildlife hospital admissions by species groups.

Cause of admission	Species group	Number of admissions	Percent of total admissions
MVA	Terrestrial birds	293	35
	Macropods	231	27.9
	Sea and water birds	189	22.6
Injury unknown cause	Sea and water birds	398	47.4
	Terrestrial birds	267	32.2
	Arboreal mammals	70	8.4
Orphaned	Arboreal mammals	219	41.4
	Sea and water birds	186	35.2
	Macropods	67	12.7
Malnourished	Sea and water birds	170	57.2
	Terrestrial birds	55	18.5
	Arboreal mammals	48	16.1
Caught accidentally	Sea and water birds	69	39
	Arboreal mammals	36	20.3
	Macropods	28	15.8
Unnecessary rescue	Sea and water birds	98	65.8
	Terrestrial birds	25	16.8

Admissions due to 'MVA', and 'orphaned' significantly increased over the study period (MVA, $F_{1,8} = 5.489$, $P < 0.05$; orphaned, $F_{1,8} = 7.386$, $P < 0.05$). Admissions of orphaned animals were clearly seasonal (Fig. 3), with admissions in spring significantly higher than admissions in autumn ($P < 0.001$), summer ($P < 0.001$), and winter ($P < 0.001$). Overall, the highest number of clinic admissions occurred in spring (n = 988, 30.2%), followed by summer (n = 954, 29.2%), autumn (n = 869, 26.4%), and winter (n = 458, 14.1%). Additionally, the number of admissions in winter was statistically lower than the number of admissions in spring ($P < 0.001$), summer ($P < 0.001$), and autumn ($P < 0.001$). This trend was also observed for sea and water birds (spring, $P < 0.001$; summer, $P < 0.05$; autumn, $P < 0.001$) and terrestrial birds (spring, $P < 0.001$; summer, $P < 0.001$; autumn, $P < 0.001$). For arboreal mammals, admissions in spring and summer were significantly higher than those in winter (spring, $P < 0.05$; summer, $P < 0.05$; autumn, $P < 0.001$). The leading cause of admission in both summer and winter was 'MVA' (n = 277/954, 29.4%; n = 164/458, 35.8%, respectively). The leading cause of admission in spring and autumn was 'orphaned' (n = 303/988, 30.7%) and 'injury unknown cause' (n = 235/869, 27%), respectively. 'Injury unknown cause', 'MVA', 'collision', 'exhausted', 'caught in fishing line', and 'dog attack' peaked in summer, while 'caught accidentally' peaked in autumn.

Outcomes of admission

The average rate of mortality across all admission types for all animals admitted was 59.1%, while the remaining admissions resulted in positive outcomes (i.e. successful release or placement in care, 40.9%) (Table 1). 'Injury unknown cause' had the highest mean mortality rate at 89.7%, followed by 'MVA' (86%) and 'malnourished' (73.7%) (Table 3). The mortality of the remaining COA categories was below 50% (range: 0.7–46.9%). 'Injury unknown cause' had the highest odds ratio for mortality at 3.58 (CI = 2.8208–4.5417), followed by 'MVA' at 2.6014 (CI = 2.1124–3.2102), and 'malnourished' at 1.1331 (CI = 0.8655–1.4835). Conversely, 'unnecessary rescue' had the highest rate of positive outcomes (99.3%), followed by 'caught accidentally' (75.7%) and 'orphaned' (46.9%). Each of these cases carried low mortality odds, with values of 0.0029 (CI = 0.0004–0.0205), 0.1358

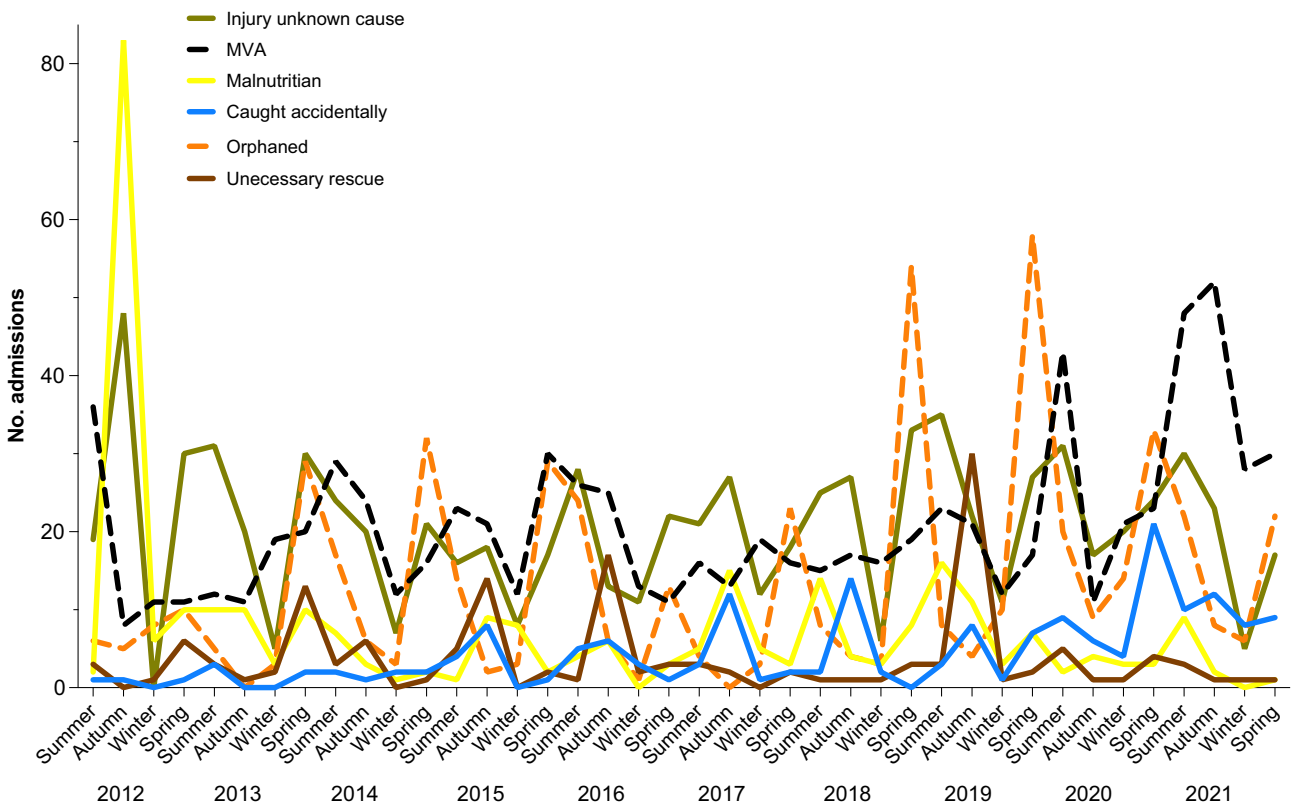

Fig. 3. Seasonal animal admission to Phillip Island Wildlife Centre for the top six causes of admission.

Table 3. Outcomes of the top six causes of admission for each multispecies group.

	MVA		Injury unknown cause		Orphaned		Malnourished		Caught accidentally		Unnecessary rescue	
Species	**Positive**	**Mortality**	**Positive**	**Mortality**	**Positive**	**Mortality**	**Positive**	**Mortality**	**Positive**	**Mortality**	**Positive**	**Mortality**
Arboreal mammals	20.8	79.2	8.6	91.4	39.3	60.7	8.3	91.7	91.7	8.3	100	0
Land mammals	41.4	58.6	33.3	66.7	100	0	0	0	100	0	100	0
Macropods	1.7	98.3	0	100	49.3	50.7	0	100	53.6	46.4	100	0
Bats	100	0	0	100	0	100	75	25	80	20	100	0
Lizards	40	60	8.3	91.7	0	0	100	0	50	50	100	0
Turtles	58.3	41.7	83.3	16.7	100	0	0	0	100	0	100	0
Sea and water birds	15.9	84.1	10.2	89.8	80	20	34.7	65.3	78.3	21.7	100	0
Terrestrial birds	15	85	10.9	89.1	50.9	49.1	20	80	59.1	40.9	96	4
Overall	14	86	10.3	89.7	53.1	46.9	26.3	73.7	75.7	24.3	99.3	0.7

(CI = 0.0955–0.193), and 0.3562 (CI = 0.6077–0.7325), respectively.

At the species level, arboreal mammals, macropods, sea and water birds, and terrestrial birds exhibited high mortality rates (>65%, range 65.3–100%) attributed to 'injury unknown cause', 'MVA', and 'malnourished'. Bats and lizards had high rates of mortality specifically for 'injury unknown cause' at 100% and 91.7%, respectively. Among the admissions, macropods affected by 'MVA' exhibited the highest odds ratio for mortality at 24.01 (CI = 8.91–64.21), followed by arboreal mammals admitted for 'malnourished' (OR = 4.65, CI = 1.67–12.99) or 'injury unknown cause' (OR = 4.51, CI = 1.95–10.55). Overall, mortality among orphaned animals was slightly below the average rate (46.9%), while mortality rates for orphaned arboreal mammals and macropods exceeded the average (60.7%, OR = 0.654, CI = 0.775–0.963 and 50.7%, OR = 0.44, CI = 0.269–0.709, respectively). Animals classified as 'caught accidentally' generally exhibited

favourable outcomes, with an average mortality rate of 24.3%. However, terrestrial birds, macropods, and lizards had much higher mortality rates compared to other species groupings: 40.9%, 46.4% and 50%, respectively. Species admitted due to 'unnecessary rescue' generally achieved a positive outcome rate of 100%. However, terrestrial birds had a mortality rate of 4%.

Discussion

This study presents a comprehensive analysis of 10 years of wildlife clinic admission data from PIWC. It builds upon an increasing understanding of the factors contributing to Australian native wildlife clinic admissions and their chances of survival. The findings reveal several key points: (1) birds are the most common animal group represented in the admissions, followed by mammals; (2) the dominant causes of admission for birds and mammals are MVAs, injuries of unknown cause, and orphaning; (3) seasonal trends in clinic admissions are observed; and, (4) causes of admission related to trauma have higher mortality rates for wildlife than other cases such as 'caught accidentally' or 'orphaned'. Overall, these results offer valuable insights into the challenges faced by Philip Island wildlife and emphasise the importance of targeted conservation strategies and interventions.

The findings of this study revealed that avian species constituted the majority of wildlife admitted to PIWC, accounting for 64.5% of all admissions, with sea and water birds the most frequently admitted bird group (59% of all birds). These findings align with previous reports from private veterinary clinics across Australia (Orr and Tribe 2018) as well as rehabilitators (Tribe and Brown 2000; Kwok *et al.* 2021) and a private veterinary clinic (Haering *et al.* 2021) in NSW, but differ from reports in SEQLD (Taylor-Brown *et al.* 2019) and Victoria (Tribe and Brown 2000), which observed higher admissions for mammalian species.

The high admissions of avian species observed in the present study is likely influenced by the unique geographical and ecological characteristics of Phillip Island. The island's location off the southern coast of Victoria provides access to diverse coastal ecosystems and habitats that offer favourable conditions for a variety of bird species, especially sea and water birds, which rely on these areas for feeding, nesting, and roosting. Further, Phillip Island serves as an important migratory pathway for many bird species, including shearwaters (the most admitted species in this study), using it as a stopover or wintering site (Phillip Island Nature Parks 2023).

The popularity of Phillip Island as a tourist destination and its associated ecotourism activities may also contribute to the high proportion of avian species admitted to PIWC. The island attracts a substantial and increasing number of visitors each year (Department of Jobs, Skills, Industry and Regions 2023), leading to increased traffic flow. This influx of vehicles on the island's roads not only raises the likelihood of MVAs involving avians and other wildlife groups, but also enhances the opportunities for human–wildlife interactions. Specifically, sea and water birds, being present near coastal areas and popular tourist sites may come into closer proximity to humans. Unfortunately, these interactions can result in potential disturbance to wildlife, including distress, accidental injuries, entanglements, or disturbances to nesting sites (Carney and Sydeman 1999; Guillemain *et al.* 2007; Shannon *et al.* 2017). Further, unnecessary rescue was a major cause of admission in this study, particularly for birds, highlighting the need for public education initiatives to reduce admissions due to this cause. Implementing strategic measures, such as placing infographics in coastal areas and popular tourist sites, offering a comprehensive list of indicators for appropriate rescues, or encouraging individuals to contact the clinic for initial assessment, could effectively alleviate stress on the clinic and ensure more efficient care for the animals.

The increasing human residency on Phillip Island over the last 10 years has likely intensified the human–wildlife interface with urban development and expansion encroaching upon natural habitats resulting in habitat fragmentation and potential population density challenges for wildlife. This increased population, coupled with high motor vehicle density, may lead to car strikes as the leading cause of animal admissions on Phillip Island. Specifically, car strikes are the primary cause of admission for land birds, land mammals, macropods and turtles and the second-highest cause for sea and water birds and arboreal mammals. This finding is consistent with previous studies conducted across Australia, which have identified car strikes as a significant threat to various species including birds, reptiles, amphibians (Scheelings 2015; Taylor-Brown *et al.* 2019; Kwok *et al.* 2021; O'Leary *et al.* 2023) and koalas (Griffiths *et al.* 2013; Gonzalez-Astudillo *et al.* 2017; Charalambous and Narayan 2020; Lunney *et al.* 2022, 2023). Given the substantial and escalating impact of car strikes on the native wildlife of Phillip Island, it is recommended that local councils take proactive steps, including maintaining roadside vegetation, reducing speed limits, and installing flight deflectors along roadsides to encourage birds to fly above vehicle height (Loss *et al.* 2014; Shilling and Waetjen 2015). Additional measures to be considered involve the implementation of management efforts such as wildlife underpasses and overpasses across roads with fencing. These initiatives would not only enhance the safety of wildlife but also contribute to human well-being, as collisions between vehicles and wildlife can lead to a significant number of human injuries and substantial damage to vehicles (Gunson *et al.* 2011; Loss *et al.* 2014; Shilling and Waetjen 2015).

Orphaning was another significant cause of admission across various species, including arboreal mammals, water birds, and macropods. These admissions exhibited a clear seasonal pattern, with a considerably higher number of cases during spring compared to other seasons. Similarly, all other causes of admission demonstrated a seasonal trend, with

significantly lower numbers during winter in comparison to other seasons. This seasonal fluctuation is observed consistently across Australia (Heathcote *et al.* 2019; Taylor-Brown *et al.* 2019; Tribe and Brown 2000; Kwok *et al.* 2021) and can be attributed to several factors, including increased activity associated with breeding and rearing of young, as well as greater movement and activity of animals during the warmer spring and summer months. Although there was an overall increase in total number of admissions when comparing 2011 and 2021, for six of the 10 years, admission rates appear to be lower than baseline (2011). This may be attributed to a combination of factors, including natural population fluctuations, stabilised public reporting patterns following an initial surge in awareness in 2011, and potential improvements in wildlife health due to shifts in food availability and predator–prey dynamics.

The most numerous species admitted were swamp wallabies, possums, short-tail shearwaters and Cape Barren geese, species currently of no conservation concern. In some cases, particularly for mammals, the high admission numbers of these species may, in part, be attributed to population density issues on the island, where wildlife may face challenges in relocating to other areas. Five endangered species were admitted throughout the study period. Of particular interest is the eastern barred bandicoot, which was introduced to Phillip Island in 2017 as part of a strategic initiative to rescue the species from extinction (Department of the Environment, Land, Water and Planning 2021). The clinic has observed 12 admissions between 2018 and 2021, with seven cases attributed to unknown causes. Addressing the unknown causes of admission for this species is important for a comprehensive understanding of the threats they face on the island. Further, collecting more data for such species through rescue, recovery, and release efforts can contribute significantly to their conservation by providing insights into risk relative to various causes of admission, location, time of year, sex, and age. This data-driven approach can enhance our understanding of the ecology of endangered and vulnerable animals, contributing valuable information for their management and conservation (Pyke and Szabo 2018).

The average rate of mortality across all admission types for all animals admitted was 59.1%, slightly higher than reported in previous Australian studies with documented mortality rates of 55.2% (Kwok *et al.* 2021) and 53.6% (Taylor-Brown *et al.* 2019) across diverse species and causes of admission. However, mortality rates exhibit considerable variation among different species and causes of admission across these studies. For example, macropods consistently show mortality rates approaching or exceeding 90% in car strike incidents (Taylor-Brown *et al.* 2019; Kwok *et al.* 2021), and avian species have shown mortality rates between 67% and 86%, depending on species (Orr and Tribe 2018; Taylor-Brown *et al.* 2019; Kwok *et al.* 2021). Conversely, turtle species have greater survivability following car strike with mortality rates of 41.7% (present study), 37.7% (O'Leary *et al.* 2023) and 56.6% (Taylor-Brown *et al.* 2019). In the present study, mortality rates associated with 'caught accidentally' were generally below 22% across species. However, mortality rates were notably high for macropods, terrestrial birds, and lizards when compared to other species groupings. This observation highlights the importance of educating and communicating information to the general public, including pool safety measures such as adding exit points and providing climbing opportunities for wildlife near drains and buildings and other hazards wildlife may encounter. Finally, 'malnourished' emerged as a relatively common cause of admission, associated with a high mortality rate among arboreal mammals, macropods, terrestrial birds, and sea and water birds. Instances of malnourishment were frequently observed during summer and autumn, although this pattern was not consistently observed across all years. Nonetheless, it may be a consequence of environmental pressures resulting from increasing global temperatures and/or population density strains; regardless, further investigation is warranted. Overall, these findings underscore the urgent need for conservation efforts and targeted interventions to mitigate the impact of tourism and reduce physical trauma incidents among wildlife populations on Phillip Island.

Conclusion

In conclusion, this 10-year analysis of wildlife clinic admissions at the Phillip Island Wildlife Clinic provides valuable insights into the primary causes, outcomes, and temporal trends of wildlife admissions in the region. The notable presence of avian species among the admissions highlights the need to address the specific challenges faced by these populations on Phillip Island. Conservation efforts should prioritise the preservation and restoration of coastal and wetland habitats, as well as the implementation of measures to minimise human–wildlife conflicts. Raising awareness among tourists and local communities about responsible wildlife interactions is also crucial. Additionally, conducting further research on avian ecology, habitat assessments, and migratory patterns specific to Phillip Island can provide detailed insights into the dynamics of avian populations, aiding in the development of targeted conservation strategies. It is anticipated that the findings of this study will contribute to the formulation of targeted conservation strategies, interventions, and public awareness campaigns aimed at mitigating these threats and promoting responsible practices that safeguard the unique biodiversity of Phillip Island for future generations.

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