Trends in anecdotal fox sightings in Tasmania accounted for by psychological factors

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Abstract

There has been little evaluation of anecdotal sightings as a means to confirm new incursions of invasive species. This paper explores the potential for equivocal information communicated by the media to account for patterns of anecdotal reports. In 2001 it was widely reported that red foxes (*Vulpes vulpes*) had been deliberately released in the island state of Tasmania (Australia), although this claim was later revealed to be baseless. Regardless, by 2013 a total of 3153 anecdotal fox sightings had been reported by members of the public and this implied the wide distribution of foxes. Between 2001-2003 a monthly media index (*MMI*) for fox-related stories was significantly linked to 15 equivocal claims (*Monthly Claims*) of physical evidence used to support the existence of a putative fox population ($P = 0.001$). Fluctuations in monthly anecdotal fox sightings were modelled by *MMI*, *Monthly Claims* and *Year* far more convincingly than biophysical factors describing seasonal

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changes in fox abundance and photoperiod ($P < 0.0001$). An annual index of fox media from 2001-2010 was also strongly associated with the yearly tally of anecdotal sightings ($P = 0.018$). The odds-ratio of sightings ranked as reliable by the fox program in any year decreased exponentially at rate 0.00643 as the total number of sightings increased ($P < 0.0001$) and was indicative of an observer-expectancy bias. Our results suggest that anecdotal sightings are highly susceptible to cognitive biases and when used to qualify species presence can contribute to flawed risk assessments. Data of known quality and precision are required to reliably confirm a unique invasive species incursion.

Introduction

Biosecurity and ecological monitoring data are sometimes *ad hoc* and reliant upon anecdotal reports and opportunistically acquired evidence (McKelvey et al. 2008; Marks et al. 2014b). Because species rarity decreases the reliability of population estimates a dependence upon anecdotal information to qualify species presence can lead to misleading inferences (McKelvey et al. 2008). Overall, there has been little critical assessment of anecdotal information as part of an evidence-based approach (Sutherland et al. 2013) for confirming invasive species incursions and directing eradication efforts.

Confusion about the conservation status of vertebrate species can arise due to poorly qualified anecdotal sightings. For instance, multiple alleged sightings of the ivory-billed woodpecker (*Campephilus principalis*) incorrectly implied that this species was widely distributed until comparatively recently although it most probably went extinct by the mid-1900s (McKelvey et al. 2008). Similarly, many anecdotal sightings of the thylacine (*Thylacinus cynocephalus*) in Tasmania (Guiler 1966; Johnson 2006) have been widely reported (Sleightholme & Campbell 2016) and used to challenge the scientific consensus that given a lack of physical evidence corroborating its presence it was extinct by 1935 (Paddle 2002; Bulte et al. 2003; Johnson 2006). Other authors argue that various anecdotal reports of thylacine after 1935 may be reliable indicators of its persistence (Sleightholme & Campbell 2016), however evidentiary standards that accept uncorroborated sightings may reduce the rigor of species presence data (Roberts et al. 2010).

The risks associated with the use of *ad hoc* sighting reports to model species distribution was practically demonstrated by a study that produced a statistically compelling habitat model incorporating anecdotal sightings of the mythical North American Sasquatch ['Bigfoot'] (Lozier et al. 2009). While most reports were attributed to the misidentification of the black bear (*Ursus americanus*), erroneous preconceptions due to cognitive biases that influenced observer judgement most likely originated from the mass media and popular culture (Lewandowsky et al. 2012). Various iconic species may similarly attract significant media attention where the impact of equivocal information and media narratives concerning their speculative presence or distribution may likewise affect observer judgement.

In 2001 claims that up to 19 foxes (*Vulpes vulpes*) from the Australian mainland had been released in the island state of Tasmania (area = 68,500 km^2) were widely communicated by the Australian and international media (Dennis 2002) despite a Tasmanian police investigation finding this claim to be

anecdotal and without any evidentiary basis (Marks et al. 2014b). Nonetheless, opportunistically acquired *post mortem* specimens of foxes (skins, carcasses and a skull) led some researchers to speculate that they originated from the claimed release in 2001 (Sarre et al. 2007). Foxes are abundant in mainland Australia which is linked to Tasmania by a daily vehicle and container ferry that docks in Melbourne [Victoria] (Plowman 2004). The routine harvesting of foxes by shooters in Victoria yielded approximately 151,000 foxes in the 2002 - 2003 period alone (Fairbridge & Marks 2005) and until November 2009 there was no specific prohibition on importing mainland fox carcasses to Tasmania (Animal-Health-Act 1995). The absence of empirically derived survey data confirming the presence of an extant fox population in Tasmania, together with several cases of hoaxing (reviewed by Marks et al. 2014c), suggested that the provenance of these opportunistically acquired *post mortem* fox specimens was equivocal at best. Anecdotal reports of foxes were heavily relied upon in the first year of the program to augment 'weight of evidence' arguments used to justify the implementation of an eradication program using fluoroacetic acid (1080) baiting (Saunders et al. 2006; Anon 2012) that was eventually expanded to the entire island (Parkes & Anderson 2009).

A media campaign that began in 2001 encouraged members of the public to report fox sightings and as of January 2013 a total of 3153 were recorded. This large tally was believed to support the existence of a widespread but cryptic fox population (Sarre et al. 2007) despite no sightings being corroborated with physical presence data indicative of an extant population. Nonetheless, anecdotal reports were used to: direct searches for foxes using scat detection dogs (Parkes & Anderson 2009); determine fox presence and distribution (Saunders et al. 2006; Sarre et al. 2007; Sarre et al. 2014) and; assess baiting effectiveness (Saunders et al. 2006).

We investigated the potential for fluctuations in anecdotal sightings to be an artifact of cognitive biases generated by the wide dissemination of equivocal claims originating with the Fox Eradication Program (FEP) and an observer-expectancy bias in the subjective rating of the quality of putative fox sightings.

Our first hypothesis was that changes in the extent of media reports concerning foxes would be highly dependent upon claims made by the FEP from 2001 - 2003 concerning corresponding physical evidence irrespective of its equivocal value (Marks et al. 2014b). We further hypothesized that anecdotal sightings of foxes arose from the misidentification of endemic fauna due to preconceptions and cognitive biases that had been generated by the dissemination of equivocal information via the media. We tested this hypothesis by modeling observed changes in monthly anecdotal sightings relative to the timing of 15 claims concerning fox presence (Appendix S1) and a corresponding index of media intensity. Our alternative model considered that trends in anecdotal sightings were due to changes in the relative abundance of an extant fox population and/or changes in the hours of darkness that would influence the successful detection of all nocturnal animals.

Methods

Terms used for modelling of monthly data

Our models involve 5 covariates or continuous variables (*Monthly Sightings, MELC, MMI, Abundance*, and *Darkness*) and two factors (*Monthly Claims* and *Year*). We define and discuss these terms below.

We defined *Monthly Sightings,* our principal variable of interest, as the monthly totals of putative fox sightings between 2001 and 2003 taken from the Fox Eradication Program (FEP) sightings database (Anon 2012) as reported by Saunders *et al.* (2006). In response to an ongoing media campaign, anecdotal fox sightings had been reported by members of the public to a dedicated FEP hotline number where the quality of each such presumed sighting was subjectively rated as either 'excellent', 'possible' or 'unlikely' without corroboration with physical evidence (Saunders et al. 2006; Parkes & Anderson 2009).

Because the influence of any claim of physical evidence on the amount of media exposure would presumably tend to decrease with time we defined the covariate *MELC* as the number of months since the most recent claim, being set to zero in any month when there was no claim. Since the first claim occurred in month 5 of 2001 *MELC* was not defined for the first 4 months.

We generated an index of monthly media, denoted *MMI*, by counting the number of articles about putative fox presence published by the four local Tasmanian newspapers (The Mercury, The Advocate, The Examiner and Tasmanian Country) each month between 2001 and 2003. The *MMI* was restricted to local print media since it was too difficult to assess the relative influence of mainland and international electronic and print media.

The red fox is an obligatory seasonal breeder and only a single litter is produced each year (Lloyd & Englund 1973; Lindstrom 1989; McIlroy et al. 2001) where the mean birth day is influenced by latitude (Lloyd & Englund 1973). In southernmost parts of mainland Australia most births occur in September and cubs are observed above ground and are highly conspicuous in October and November, corresponding to a seasonal maxima in population abundance (Marks & Bloomfield 1999). High rates of juvenile and yearling mortality in the following months cause the population to progressively decline to a minimum just prior to the birth of cubs in the following breeding season (Saunders & McLeod 2007). We developed an index of relative fox abundance, denoted *Abundance*, using results from a study of monthly changes in the abundance of foxes over a 12 year period in a rural northern hemisphere study, adjusted for the southern hemisphere. (Marks 2001)

All endemic Tasmanian mammals likely to be misidentified as foxes are nocturnal (see discussion) and red foxes are also primarily nocturnally active in both rural and urban habitats (Phillips & Catling 1991; Doncaster & Macdonald 1997). We defined the covariate *Darkness* as the mean hours of darkness each month at the latitude of Launceston (41.4^{o} S) thereby accounting for the changing duration of activity for all nocturnal fauna.

The factor *Monthly Claims* defined whether or not in any given month there had been at least one claim of physical evidence relating to the existence of foxes. Between 2001 and 2003 there were 15

claims made by the FEP that attested to the existence of putative physical evidence of foxes in Tasmania. A retrospective analysis determined that 9 of 11 cases were associated with between 1-5 criteria indicative of unreliable empirical data. This included the absence of supportive physical evidence (n=3), the involvement of anonymous persons in the provision of materials (n=6) or misreported laboratory analysis (n=1) (Marks et al. 2014b). A further 4 claims were attributed to the FEP between 2001 and 2003 that attested to the existence of physical evidence that were not included in the latter list of FEP evidence (Appendix S1).

It was clear from all plots of the *Monthly Sightings* and the *MMI* that both of these variables were consistently higher in 2002 compared to the other years, in part because the first claims were not generated until May 2001. Hence our analyses included a factor *Year* having 3 levels, corresponding to each year between 2001 and 2003.

Model for monthly media index

Since the *MMI* was a continuous variable we fitted a linear model with *Year* and *Monthly Claims* as factors and *Abundance, Darkness, MELC* and *Monthly Sightings* as covariates. As most instances of putative physical evidence of foxes occurred in 2001 the model included a possible interaction between *Year* and *Monthly Claims*. We first fitted a full model including all possible terms and then used 'stepwise selection' to select the best reduced model as judged by Mallow's C_p criterion (Mallows 1973).

Model for anecdotal sightings

We modelled *Monthly Sightings* using a Generalised Linear Model with Poisson error distribution (Zar 1999) starting with a full model involving all plausible terms and then used 'stepwise selection' to find the best reduced model guided by the Akaike Information Criteria [AIC] (Akaike 1979). The full model comprised *Year* and *Monthly Claims* as factors and *MMI*, *Abundance, Darkness* and *MELC* as covariates and also included a possible interaction between *Year* and *Monthly Claims*. Since *MMI* had generally lower values in *Year 1* (2001) the model also included a possible interaction between *MMI* and *Year*.

Counterfactual analysis

With the presence of an extant fox population we would expect changes in monthly sightings to correspond to changes in their relative abundance (*Abundance*). Differences in the comparative hours of darkness (*Darkness*) each month would be anticipated to influence sightings of both misidentified species and foxes. Alternatively, anecdotal sightings could be accounted for exclusively by psychological factors such as *Monthly Claims*, *MMI*, *MELC* and *Year* that are more likely to be associated with cognitive biases responsible for incorrectly assigned sightings. We performed a counterfactual analysis by first subdividing the predictors for our model for *Monthly Sightings* into either "biophysical" (Group B comprising *Abundance* and *Darkness*) or "psychological" (Group P

comprising *Monthly Claims*, *MMI*, *MELC* and *Year*) indicators and then examining the corresponding Analysis of Deviance.

Annual media index and sightings

We compared trends in the reporting of a tally of annual sightings (*Annual Sightings*) between 2001 and 2010 with two annual media indices (AMI) developed from counts of Australian media pages for each year in a national newspaper archive (Trove: National Library of Australia, Canberra). We searched this database with the terms 'Tasmania + foxes' or 'Tasmanian foxes' found in all Australian environmental media, giving the total number of pages published in each year containing the term. We examined the relationship between AMI and Annual Sightings using a reduced major axis regression (Sokal & Rohlf 1981; Warton et al. 2006).

The proportion of annual sightings deemed by the FEP to be excellent in quality declined from 31% in 2001 to 5% in 2010. To examine the nature of this decrease, we fitted a Generalised Linear Model for binomial proportions with the default logit (log-odds) transformation and using data from only the 6 years where both data were available (Zar 1999).

Results

Monthly print media index

Anecdotal sightings (*Monthly Sightings*) were eliminated from the full model after stepwise selection, implying that the number of reported sightings for each month did not influence the *MMI*. In the final reduced model only *Year* ($P = 0.001$) and the covariate *MELC* ($P < 0.001$) were significant model terms (Appendix Table S2a). Confidence intervals confirm that *MMI* was generally higher in Year 2 than in the other years. The negative coefficient for *MELC* showed that there is a spike in *MMI* whenever *MELC* is zero (a claim is made in the current month) and then *MMI* decreases linearly until the next claim (Appendix Table S2b)

Monthly fox sightings

After stepwise selection the final reduced model included the factors *Year* ($P < 0.0001$) and *Monthly Claims* ($P < 0.0001$) and *MMI* ($P = 0.004$) with a significant interaction between *MMI* and *Year* [$P < 0.005$] (Table 1a). The effect of *MMI* was significantly different due to *Year* with *MMI* having a positive effect in Year 1, a negligible effect in Year 2 and negative effect in Year 3 (Table 1b). The fitted values for the expected number of anecdotal sightings with 95% confidence limits closely corresponded with the observed trend in *Monthly Sightings* (Fig. 1).

Counterfactual analysis

Relative to the Null Hypothesis the collective effect of the Group B variables was significant ($\chi^2 = 15.55$, df = 2, p = 0.0002) primarily due to *Darkness* (p=0.0003) while *Abundance* alone was not significant (Table 2). *MELC* was non-significant in the full model and was removed allowing data from all 36 months to be used in the counterfactual analysis. The subsequent Analysis of Deviance showed that the Group P variables accounted overwhelmingly for anecdotal sightings compared to the

Group B variables in the reduced model [χ^2 = 122.1, df = 6, P < 0.0001] (Table 2). All standard diagnostic residual plots, including tests for serial correlations in the residuals, confirmed that the reduced model was satisfactory with no evidence of under-fitting or over-fitting.

Annual fox sightings

The time series of both annual media indices based upon the search terms were highly correlated. The AMI based upon the search term 'Tasmanian foxes' was strongly correlated with the annual sightings recorded between 2001-2010 in the reduced major axis regression [Spearman rank correlation = 0.685, *P* = 0.018: one-sided] (Fig 2a). There was a strong linear relationship between this AMI and annual sightings as determined by reduced major axis regression [p = 0.005] (Fig. 2b). At the inception of the program in 2001, 31% of sightings were considered to be excellent in quality whilst only 5% were given a similar rating by 2010 despite a four-fold increase in the annual sighting tally. The log-odds (logarithm of the odds-ratio) for a sighting being subjectively assessed to be excellent in quality in any year decreased linearly at the rate of 0.00643 (95% CI = 0.0050, 0.0079) where the corresponding fitted proportions and confidence limits are shown graphically by the curve in Fig.3.

Discussion

Accounting for anecdotal fox sightings

Changes in the period of darkness each month significantly influenced anecdotal reports consistent with an anticipated trend for the activity rhythms of nocturnal animals, irrespective of whether they were fox sightings or misidentified endemic fauna. However, the factor that described predictable monthly changes in relative fox abundance (*Abundance*) was non-significant and failed to account for the irregular pattern of anecdotal sightings. In contrast, psychological factors such as the timing of claims made by the fox program concerning putative physical evidence together with the index of local media in the same month convincingly modelled the observed trend in monthly anecdotal sightings from 2001 - 2003.

As the first claim of fox presence was not promoted until May 2001 (Dennis 2002) this may explain why the *MMI* and number of anecdotal sightings in that year were significantly lower than 2002 and 2003. Changes in the factor *Year* may have nonetheless reflected the fluctuating level of community 'awareness' and changing 'belief' in the existence of a fox population. Our model is necessarily limited by an inability to develop meaningful factors that account for changing beliefs that may have affected trends in anecdotal sightings. Communication theory demonstrates that public beliefs and attitudes will be influenced most effectively by information arising from sources that are assumed to be credible (Pornpitakpan 2004). Attitudes will fluctuate in response to new information (Happer & Philo 2013) and a wide range of variables such as the ability and motivation of people to process it as well as the assumed expertise of those providing conflicting analysis (Petty et al. 2002). The contested quality of the physical evidence remains central to the controversy about the presence of foxes in Tasmania, especially given that no credible empirical data was found to corroborate 13 of 15 claims made by the FEP between 2001 and 2003 pertaining to the existence of an extant fox

population [Appendix S1] (Marks et al. 2014b). However, a failure to fully define psychological factors that influence changing public beliefs necessarily reduces the power of our model. Yet in the absence of probability or power estimates associated with the use of anecdotal fox sightings as *de facto* fox presence data our hypothesis, that does not require the existence of an extant fox population, should be preferred at least until anecdotal fox sightings are corroborated with irrefutable empirical evidence.

A strong and significant regression of the annual tally of sightings with the index of annual fox media between 2001 and 2010 suggests that this media index alone accurately predicted the number of anecdotal fox sightings received in each year. The direction of causality was assumed to follow that found for monthly anecdotal sightings and also because annual sighting tallies were only revealed retrospectively without any detectable lag in their influence upon annual media.

The proportion of annual sightings subjectively rated as 'excellent' by FEP staff was clearly inversely correlated with the total number of annual sightings received. At the commencement of the fox program in Tasmania a large proportion of anecdotal sightings were considered to be reliable, yet as the number of reports increased relatively fewer were rated as such. Without a rationale for why members of the public would become less reliable in identifying foxes over time, the significant change in the log odds was suggestive of an observer-expectancy bias that has previously been identified as cause of systematic error in wildlife surveys due to the changing motivational state of the observer (Balph & Balph 1983).

Given the absence of empirical data corroborating any anecdotal fox sightings, and their predictability based upon a media index and the timing of equivocal claims of fox presence, trends in anecdotal reports cannot be assumed to reflect changes in fox abundance as was suggested to have occurred after poison baiting between 2002-2005 (Saunders et al. 2006). In this instance the observed decline in anecdotal sightings was presumed to be a population response when it was more likely to have followed a reduction in the annual media index over the same period that was also not associated with any claims pertaining to putative physical evidence of foxes between 2004 and 2005 (Fig. 2a).

Why do people report seeing animals that aren't there?

Anecdotal reports of rare or cryptic animals are subject to a range of environmental, physiological and psychological influences (Bourdy et al. 1991) that account for their notorious unreliability (Wiseman et al. 1995; French 2003; Aubry 2006). Such reports may be influenced by cognitive bias (Tourangeau 2003) and misidentification and misclassification of species (Hull et al. 2010) or manipulation by hoaxing (Macdonald & Halliwell 1994; Reynolds & Short 2003). Typically, reports of unqualified phenomenon are based on quickly formed beliefs influenced by prior expectations and preconceptions. Wide dissemination of unsubstantiated information (Bartholomew 2001), often through the mass media (Lewandowsky et al. 2012), risks the development of biases where the conjunction of many unsubstantiated or uncertain reports are thought to infer greater feasibility, causality and higher probability that an unqualified phenomena exists (Tversky & Kahneman 1983). A large volume of anecdotal evidence may appear confirmatory, self-evident and extrapolative even

if it is probabilistically unlikely (Fischbein & Schnarch 1997) and subjectively biased.

A large body of anecdotal reports collated for three cryptic and rare species in North America was not indicative of their presence (McKelvey et al. 2008) and the experience in Australia and New Zealand parallels this finding. Approximately 380 reports of the extinct thylacine were recorded between 1953-1990 in Tasmania (Johnson 2006) and also from mainland Australia (Rounsevell & Smith 1982) with more than 200 recorded in Western Australia by 1998 (Douglas 1990; Heberle 2004). A private research group has compiled some 3800 reports for mainland Australia (Australian Rare Fauna Research Association: http://www.arfra.org). Irrespective of the impressive number of anecdotal reports no irrefutable physical evidence has been presented to corroborate a single sighting. In New Zealand similar anecdotal reports of extinct moa (Aves: Dinornithiformes) are regularly reported yet attributed to a combination of genuine error and hoaxing (Anderson 1989). Wide belief in the presence of a wild population of exotic big cats in Victoria, such as the puma (*Puma concolor*), is also linked to many uncorroborated anecdotal sightings that have received a high level of media attention even though no primary evidence of unquestionable provenance has been presented to confirm their presence (Menkhorst & Morison 2012).

Anecdotal accounts of new invasive species incursions may involve observers who have little or no familiarity with the species in question where the potential exists to confuse sightings of animals with similar morphology. Most Tasmanian residents will be unfamiliar with the red fox, unlike mainland Australia where foxes are widely distributed (Anon 2002), frequently sighted in capital cities (Marks & Bloomfield 1999) and commonly encountered as road kill (Abson & Lawrence 2003; Taylor & Goldingay 2004; Coffin 2007). In Tasmania, nocturnal species such as the brush tail possum (*Trichosurus vulpecula:* the specific name implying 'fox-like'), feral cat (*Felis catus*) and spotted-tailed quoll (*Dasyurus maculatus*) may be easily confused with foxes given morphological similarities (Strahan 1981) especially with a reduced ability to determine distance and relative size at night (Bourdy et al. 1991). In Tasmania the brush-tail possum's predilection for terrestrial foraging (MacLennan 1984; Strahan 1991), its wide distribution (Munks et al. 2004), high density, occurrence of the rufus-brown coat variation (Strahan 1983; Kerle 1984) and visibility along roads in the evening (Hobday & Minstrell 2008) suggests that the risk of misidentification is significant.

Conclusions

Observed trends in monthly anecdotal fox sightings in Tasmania were convincingly modelled using the timing of equivocal claims made by the FEP and an index of media reports generated over the same period. Both the reporting and subjective assessment of uncorroborated anecdotal sightings can be affected by cognitive biases so that their use as presence data may contribute to flawed assessments of invasive species presence.

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Table 1. (a) Analysis of Deviance for the reduced model of monthly anecdotal fox sightings (*Monthly Sightings*) using *Year, Monthly Claims, MMI* and *Year* × *MMI interaction* with (b) corresponding coefficients that define the intercept and slope of the linear relationship for each Year.

(a)

Variable	df	Deviance	LRT	*p*
Year	2	119.38	73.38	< 0.0001
Monthly Claims	1	56.60	10.60	< 0.0001
MMI	1	54.10	8.10	0.0044
Year:MMI	2	56.80	10.81	0.0045
Residual	29	46.00		

(b)

Coefficient	Estimate	SE	CI	*p*
Intercept (1)	1.197	0.191	(0.814, 1.579)	< 0.0001
MMI (1)	0.032	0.011	(0.010, 0.053)	0.0032
Intercept (2)	2.781	0.115	(2.551, 3.011)	< 0.0001
MMI (2)	0.007	0.006	(-0.005, 0.018)	0.2629
Intercept (3)	2.777	0.136	(2.506, 3.048)	< 0.0001
MMI (3)	-0.044	0.023	(-0.090, 0.001)	0.0511
Monthly Claims	0.340	0.103	(0.133, 0.546)	0.00099

Table 2: Analysis of Deviance for assessing the collective effect of psychological factors (Group P) relative to effect of biophysical factors (Group B) and the Null Hypothesis.

Models	Residual df	Residual Deviance	df	Deviance	*p*
Null	35	175.52			

Group B: *Abundance* only	34	173.43	1	2.09	0.148
Group B: *Darkness* only	34	164.16	1	11.36	0.0003
Group B (Total)	33	160.37	2	15.55	0.0002
Groups B and P	27	38.30	6	122.07	< 0.0001

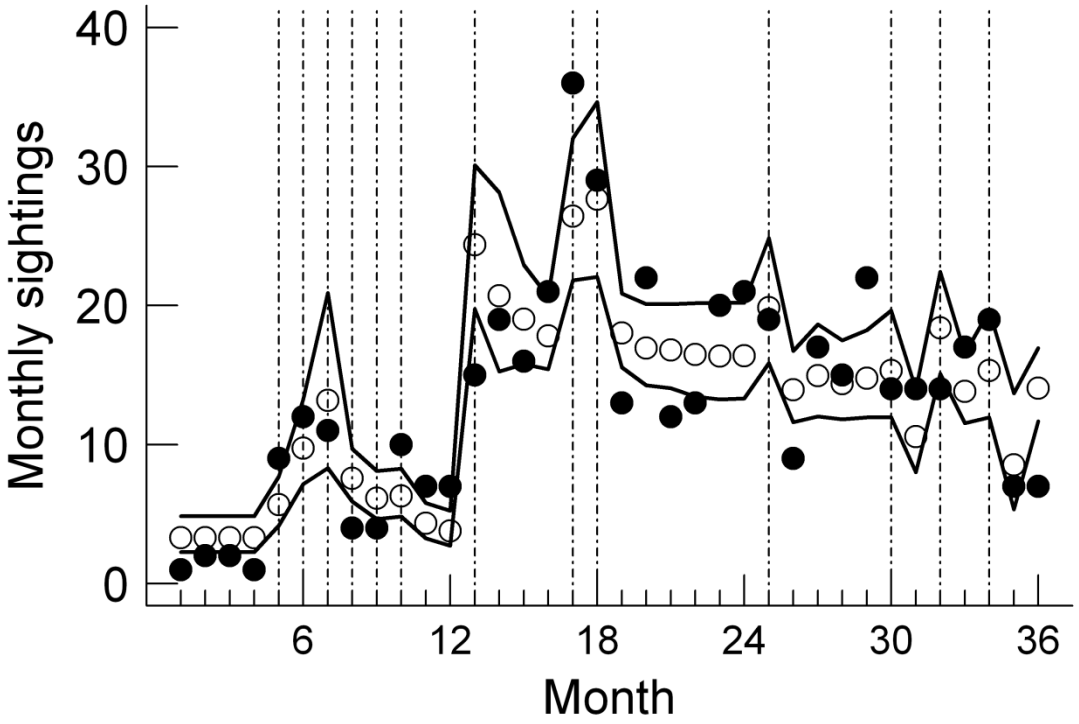

Fig. 1. Point-wise 95% confidence limits for the model of *Monthly Sightings* (solid line) with observations (●) and fitted values (○) based upon the final model defined by Table 1 with co-factors *MMI*, *Monthly Claims* (vertical dashed lines indicating when there was a *Claim*) and *Year*.

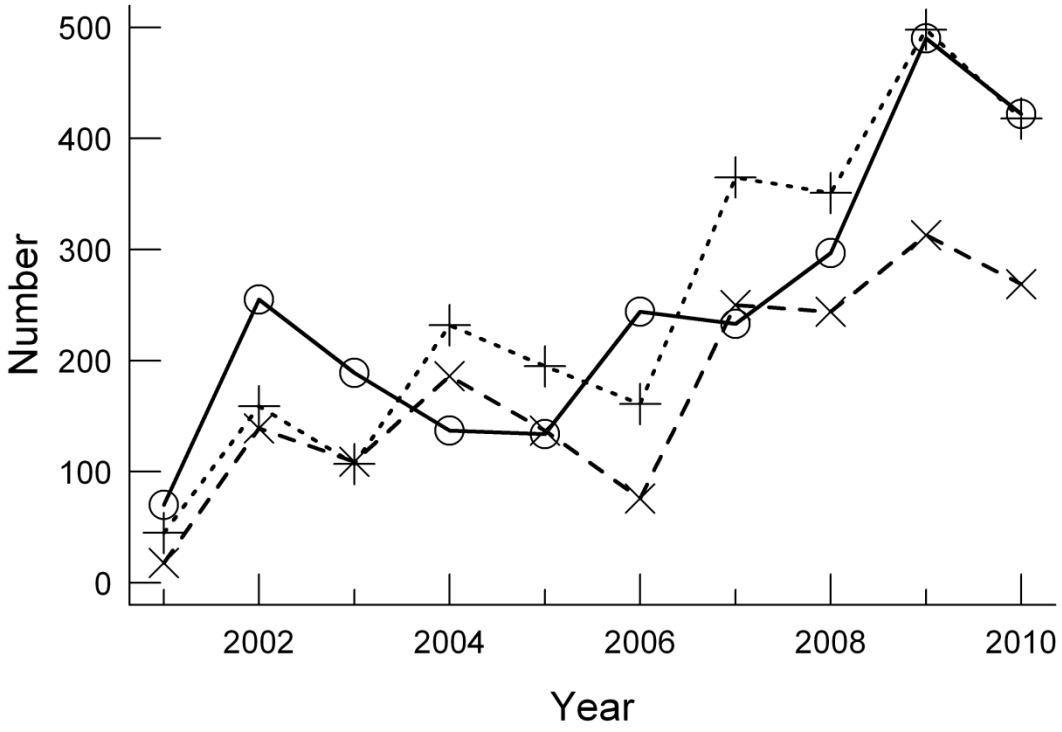

Fig. 2a. Time series of all anecdotal fox sightings (○) with the total number of media pages published in Australia with the search term 'Tasmania + foxes' (×) or 'Tasmanian foxes' (+) between 2001 and 2010.

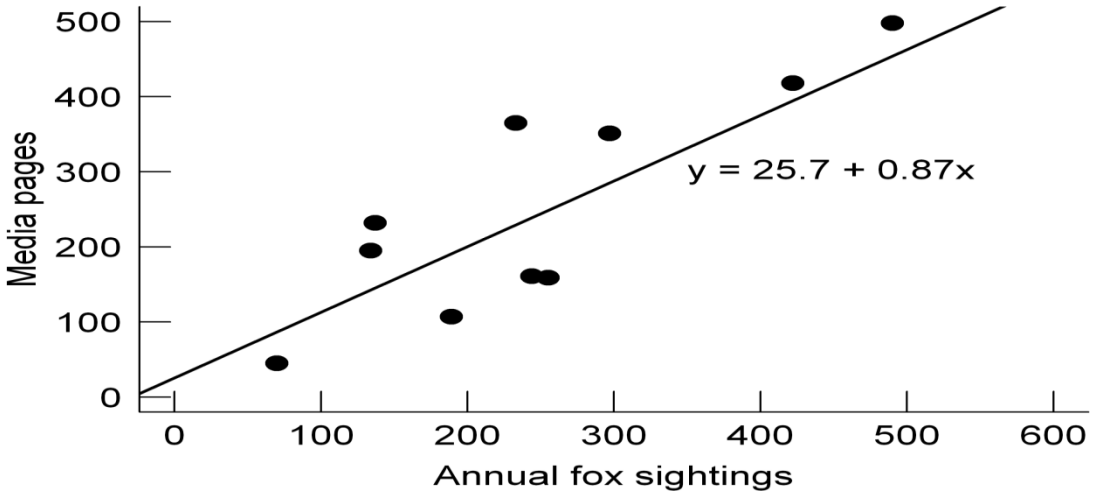

Fig. 2b. Reduced major axis regression of the total number of archived environmental media pages containing the search terms 'Tasmanian foxes' against the annual tally fox sightings from 2001 to 2010 Permutation test for slope of the line gives *P* =0.005.

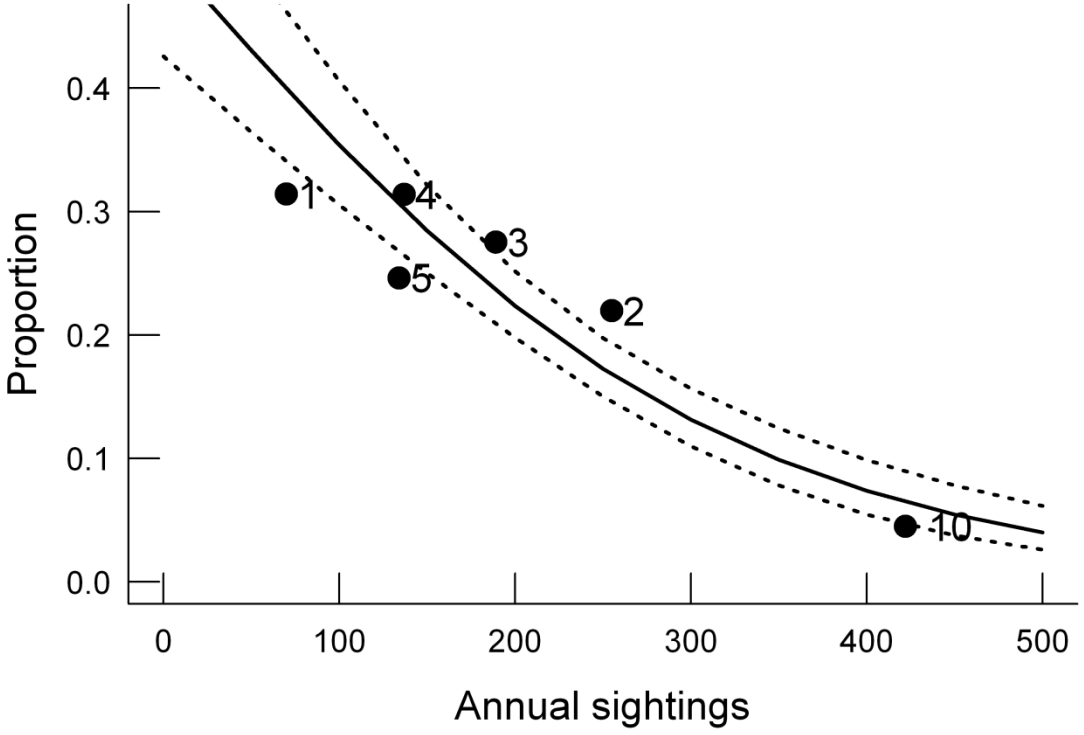

Fig. 3. Fitted binomial model for the proportion of annual sightings subjectively judged as reliable in quality against the total number in each year (Year: 1 = 2001, 2 = 2002, 3 = 2003, 4 = 2004, 5 = 2005, 10 = 2010) with the upper and lower 95% confidence limits.

References

Abson RN, Lawrence RE. 2003. Monitoring the use of the Slaty Creek wildlife underpass, Calder Freeway, Black Forest. Pages 303-308 in Irwin CL, Garrett P, and McDermott KP, editors. Proceedings of the 2003 International Conference on Ecology and Transportation. North Carolina State University, Raleigh.

Akaike H. 1979. A Bayesian extension of the minimum AIC procedure of autoregressive model fitting. Biometrika **66**:237-242.

Anderson A. 1989. On evidence for the survival of moa in European Fiordland. New Zealand Journal of Ecology **12**:39-44.

Animal-Health-Act. 1995. Animal Health Act 1995. Tasmanian Government Printer, Hobart.

Anon 2002. European red fox (*Vulpes vulpes*). Australian Government Publisher, Canberra.

Anon. 2012. Foxes in Tasmania. Department of Primary Industries, Parks, Water and Environment, Hobart.

Aubry KB. 2006. The importance of obtaining verifiable occurrence data on forest carnivores and an interactive website for archiving results from standardized surveys. Pages 159-1176 in

M.Santos-Reis, Proulx G, Birks JDS, and O'Doherty EC, editors. *Martes* in carnivore communities. Alpha Wildlife, Sherwood Park.

Balph DF, Balph MH. 1983. On the psychology of watching birds: the problem of observer-expectancy bias. The Auk **100**:755-757.

Bartholomew RE 2001. Little green men, meowing nuns, and head-hunting panics: a study of mass psychogenic illness and social delusion. McFarland and Co, Jefferson.

Bourdy C, Cottin F, Monot A. 1991. Errors in distance appreciation and binocular night vision. Ophthalmic and Physiological Optics **11**:340-349.

Bulte EH, Horan RD, Shogren JF. 2003. Is the Tasmanian tiger extinct? A biological-economic re-evaluation. Ecological Economics **45**:271-279.

Coffin AW. 2007. From roadkill to road ecology: A review of the ecological effects of roads. Journal of Transport Geography **15**:396-406.

Dennis C. 2002. Baiting plan to remove fox threat to Tasmanian wildlife. Nature **416**:357-357.

Doncaster C, Macdonald D. 1997. Activity patterns and interactions of red foxes (*Vulpes vulpes*) in Oxford city. Journal of Zoology **241**:73-87.

Douglas AM. 1990. The Thylacine: a case for current existence on mainland Australia. Cryptozoology: Interdisciplinary Journal of the International Society of Cryptozoology **9**:13.

Fairbridge D, Marks CA 2005. Vertebrate Pest Research: Evaluation of the 2002/03 Victorian Fox Bounty Trial. Primary Industries Research Victoria, Department of Primary Industries.

Fischbein E, Schnarch D. 1997. The evolution with age of probabilistic, intuitively based misconceptions. Journal for Research in Mathematics Education **28**:96-105.

French C. 2003. Fantastic memories: The relevance of research into eyewitness testimony and false memories for reports of anomalous experiences. Journal of Consciousness Studies, 10 **6**:153-174.

Guiler ER. 1966. In Pursuit of the Thylacine. Oryx **8**:307-310.

Happer C, Philo G. 2013. The role of the media in the construction of public belief and social change. Journal of Social and Political Psychology **1**:321-336.

Heberle G. 2004. Reports of alleged thylacine sightings in Western Australia. Conservation Science Western Australia **5**:1.

Hobday AJ, Minstrell ML. 2008. Distribution and abundance of roadkill on Tasmanian highways: human management options. Wildlife Research **35**:712-726.

Hull JM, Fish AM, Keane JJ, Mori SR, Sacks BN, Hull AC. 2010. Estimation of species identification error: Implications for raptor migration counts and trend estimation. The Journal of Wildlife Management **74**:1326-1334.

Johnson C 2006. Australia's Mammal Extinctions: a 50000 year history. Cambridge University Press, Cambridge.

Kerle J. 1984. Variation in the ecology of *Trichosurus*: its adaptive significance. Pages 115-128 in Smith A, and Hume I, editors. Possums and gliders. Surrey Beatty & Sons, Chipping Norton.

Lewandowsky S, Ecker UK, Seifert CM, Schwarz N, Cook J. 2012. Misinformation and its correction continued influence and successful debiasing. Psychological Science in the Public Interest **13**:106-131.

Lindstrom E. 1989. Food limitation and social regulation in a red fox population. Ecography **12**:70-79.

Lloyd H, Englund J. 1973. The reproductive cycle of the red fox in Europe. Journal of Reproduction and Fertility (Supplement) **19**:119.

Lozier J, Aniello P, Hickerson M. 2009. Predicting the distribution of Sasquatch in western North America: anything goes with ecological niche modelling. Journal of Biogeography **36**:1623-1627.

Macdonald D, Halliwell E. 1994. The rapid spread of red foxes, *Vulpes vulpes*, on the Isle of Man. Global Ecology and Biogeography Letters **4**:9-16.

MacLennan D. 1984. The feeding behaviour and activity patterns of the brushtail possum, *Trichosurus vulpecula*, in an open eucalypt woodland in southeast Queensland. Pages 155-161 in Smith A, and Hume I, editors. Possums and Gliders. Surrey Beatty in association with the Australian Mammal Society, Chipping Norton, NSW.

Mallows C. 1973. Some remarks of Cp. Technometrics **15**:661-675.

Marks CA. 2001. Bait-delivered cabergoline for the reproductive control of the red fox (*Vulpes vulpes*): estimating mammalian non-target risk in south-eastern Australia. Reproduction, Fertility and Development **13**:499-510.

Marks CA, Bloomfield TE. 1999. Distribution and density estimates for urban foxes (*Vulpes vulpes*) in Melbourne: implications for rabies control. Wildlife Research **26**:763-775.

Marks CA, Edwards I, Obendorf D, Pereira F, Hall GP. 2014a. Did 'precautionary'1080 baiting have a realistic potential to eradicate Red Fox (*Vulpes vulpes*) in Tasmania without *in situ* monitoring data? Ecological Management & Restoration **15**:196-203.

Marks CA, Obendorf D, Pereira F, Edwards I, Hall GP. 2014b. Opportunistically acquired evidence is unsuitable data to model fox (*Vulpes vulpes*) distribution in Tasmania. Wildlife Society Bulletin **38**:757–766.

McIlroy J, Saunders G, Hinds LA. 2001. The reproductive performance of female red foxes, *Vulpes vulpes*, in central-western New South Wales during and after a drought. Canadian Journal of Zoology **79**:545-553.

McKelvey KS, Aubry KB, Schwartz MK. 2008. Using anecdotal occurrence data for rare or elusive species: the illusion of reality and a call for evidentiary standards. BioScience **58**:549-555.

Menkhorst P, Morison L 2012. Assessment of evidence for the presence in Victoria of a wild population of ,'big cats'. Arthur Rylah Institute for Environmental Research, Heidelberg.

Munks S, Mooney N, Pemberton D, Gales R, Goldingay R, Jackson S. 2004. An update on the distribution and status of possums and gliders in Tasmania, including off-shore islands. Pages 111-129 in Goldingay R, and Jackson S, editors. The Biology of Australian Possums and Gliders. Surrey Beatty and Sons, Chipping Norton.

Paddle R 2002. The last Tasmanian tiger: the history and extinction of the thylacine. Cambridge University Press, Melbourne.

Parkes J, Anderson D 2009. Review of the Program to Eradicate Foxes (*Vulpes vulpes*) from Tasmania. Landcare Research, Lincoln.

Petty RE, Priester JR, Brinol P. 2002. Mass media attitude change: Implications of the elaboration likelihood model of persuasion. Media effects: Advances in theory and research **2**:155-198.2002.

Phillips M, Catling P. 1991. Home range and activity patterns of red foxes in Nadgee Nature Reserve. Wildlife Research **18**:677-686.

Plowman P 2004. Ferry to Tasmania: A Short History. Rosenberg, Kenthurst.

Pornpitakpan C. 2004. The persuasiveness of source credibility: A critical review of five decades' evidence. Journal of Applied Social Psychology **34**:243-281.

Reynolds JC, Short MJ. 2003. The status of foxes *Vulpes vulpes* on the Isle of Man in 1999. Mammal Review **33**:69-76.

Roberts DL, Elphick CS, Reed JM. 2010. Identifying anomalous reports of putatively extinct species and why it matters. Conservation Biology **24**:189-196.

Rounsevell D, Smith S. 1982. Recent alleged sightings of the Thylacine (Marsupialia, Thylacinidae) in Tasmania. Carnivorous Marsupials **1**:233-236.

Sarre SD, MacDonald AJ, Barclay C, Saunders GR, Ramsey DSL. 2014. Foxes are now widespread in Tasmania: DNA detection defines the distribution of this rare but invasive carnivore. Journal of Applied Ecology **50**:459-468.

Sarre SD, Walsch R, Aitken N, Foster A, Mooney N. 2007. DNA detection of foxes to prevent establishment in Tasmania. Page 44 in Witmer GW, Pitt WC, and Fagerstone KA, editors. Managing Vertebrate Invasive Species: Proceedings of an International Symposium. USDA/APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, Colorado.

Saunders G, Lane C, Harris S, Dickman C 2006. Foxes in Tasmania. Invasive Animals Cooperative Research Centre, Canberra.

Saunders G, McLeod L 2007. Improving fox management strategies in Australia. Bureau of Rural Sciences Canberra, Australia.

Sleightholme SR, Campbell CR. 2016. A retrospective assessment of 20th century thylacine populations. Australian Zoologist **38**:102-129.

Sokal RR, Rohlf F. 1981. Biometry (2nd edn). New York: WH Feeman and Company **668**.

Strahan R 1981. A dictionary of Australian mammal names. Angus and Robertson, London.

Strahan R 1983. The Australian Museum complete book of Australian mammals. Angus and Robertson, London.

Strahan R 1991. Complete Book of Australian Mammals. Angus and Robertson, Sydney.

Sutherland WJ, Spiegelhalter D, Burgman MA. 2013. Twenty tips for interpreting scientific claims. Nature **503**:335-337.

Taylor BD, Goldingay RL. 2004. Wildlife road-kills on three major roads in north-eastern New South Wales. Wildlife Research **31**:83-91.

Tourangeau R. 2003. Cognitive aspects of survey measurement and mismeasurement. International Journal of Public Opinion Research **15**:3-7.

Tversky A, Kahneman D. 1983. Extensional versus intuitive reasoning: The conjunction fallacy in probability judgment. Psychological Review **90**:293.

Warton DI, Wright IJ, Falster DS, Westoby M. 2006. Bivariate line- fitting methods for allometry. Biological Reviews **81**:259-291.

Wiseman R, Smith M, Wisman J. 1995. Eyewitness testimony and the paranormal. Skeptical Inquirer. CSI, Amherst (New York).

Zar JH 1999. Biostatistical analysis. Prentice Hall Upper Saddle River, NJ.