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Letter to the Editor

Flesh-footed shearwater decline on Lord Howe: Rebuttal to Lavers et al. 2019

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We refer to '*Changes in technology and imperfect detection of nest contents impedes reliable estimates of population trends in burrowing seabirds*' by Lavers et al. (2019). This paper reports on a recent (2018) survey of the threatened Flesh-footed Shearwater (*Ardenna carneipes*) on Lord Howe Island. The 2018 estimate is then compared with estimates from three previous surveys (in 1978, 2002 and 2009) to examine population trends. The paper's resulting conclusion, "*that the Flesh-footed Shearwater population on Lord Howe has decreased by up to 50% in the last decade*" we believe to be both fallacious and unjustified based on the data presented.

The 2018 survey used a similar approach to that of the previous three surveys (Fullagar and Disney, 1981; Priddel et al., 2006; Reid et al., 2013): mapping burrow distribution, counting burrows to determine burrow density, and inspecting burrows using a burrowscope to determine occupancy rate. The exception being the 1978 survey that did not assess occupancy rate, but assumed an occupancy rate of 50% (an approximation based on data from seabird colonies worldwide).

Lavers et al. (2019) estimate the population of Flesh-footed Shearwater on Lord Howe Island to be 22,654 (range 8156–37,909) breeding pairs in 2018, an estimate that, given the substantial errors involved, is roughly consistent with those from the three previous surveys (Table 1). If anything, the 2018 data indicate a recent population increase, along with an increase in colony area, burrow number and burrow density.

Contrary to the data, Lavers et al. (2019) conclude that the population has declined by up to 50% in the last decade. They base this conclusion on their belief that *"previous surveys likely underestimated true occupancy because of technological challenges"*. They justify this belief by comparing the effectiveness of two different versions of burrowscope; one of which is obviously fit-for-purpose (i.e., it provides a clear image of the contents of the burrow), the other is obviously not (i.e., the image is inadequate to determine the contents of the burrow; see Figure 2 in Lavers et al., 2019).

Without explanation or justification, Lavers et al. (2019) presume that the two previous surveys (2002 and 2009) utilised burrowscopes comparable to the one that they demonstrated to be not fit-for-purpose (Sextant Technologies scope). This assumption is incorrect. Both previous surveys used bespoke burrowscopes built by skilled technicians at university workshops, using the best available components sourced from around the globe. These burrowscopes may have relied on monochrome monitors of lower resolution than what is available today, but the images produced were no less informative in assessing burrow occupancy. The only downside to these devices was the excessive bulk and weight of the power source. We concede that occupancy rates could not be determined with complete accuracy, but this, as always, was due to the structure

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Table 1
Total colony area, number of burrows, burrow density (mean ± SE), occupancy rate (proportion of burrows containing breeding pairs) and abundance for Flesh-footed Shearwaters on Lord Howe Island.

Year	Area (ha)	Estimated # of burrows	Burrow density (m^{-2})	Occupancy rate (%)	Estimated # of pairs	Source
1978	37.75	36995	0.098 ± 0.016	Not measured	20,000[a] (20,000–40,000)	Fullagar and Disney (1981)
2002	24.31	29853	0.123 ± 0.024	58	17,462	Priddel et al. (2006)
2009	24.73	27323	0.110 ± 0.008	67 ± 4	16,267 (11,649–21,250)	Reid et al. (2013)
2018	31.63	42372	0.134 ± 0.035[b]	53 ± 5	22,654 (8156–37,909)	Lavers et al. (2019)

[a] Based on assumed 50% occupancy rate.
[b] Calculated from (active burrow density)/(occupancy rate).

and tortuosity of the burrow, not the performance of the burrowscope. Lavers et al. (2019) correctly acknowledge this limitation applies to all burrowscopes, even the most modern.

In Lavers et al. (2019), data are not tabulated or presented clearly, but the authors claim that the not-fit-for-purpose burrowscope (Sextant) used in their comparative study, detected approximately half of what was detected with the fit-for-purpose burrowscope (EMS2015 Gopher Tortoise Camera System). Being familiar with the Sextant burrowscope and its severe limitations, we accept this conclusion. One of the problems the authors identified with the Sextant burrowscope was its wireless connectivity with the monitor, particularly in deep burrows. This data transmission issue is clearly evident in the horizontal fragmentation of the image shown in Figure 2 of Lavers et al. (2019). However, neither of the burrowscopes used previously (in 2002 and 2009) employed this technology; both were hard-wired. Also, the Sextant burrowscope is only 2 m long. Flesh-footed Shearwater burrows on Lord Howe Island can reach 3 m in length. Accordingly, both of the burrowscopes used previously exceeded 3 m in length.

Without justification, Lavers et al. (2019) assume that detection rates in 2002 and 2009 were similar to that using the Sextant (not fit-for-purpose) burrowscope (i.e., about half of that achieved using a more appropriate device). This leads them to deduce (by statistical means that are not clearly articulated) that past population estimates would have been 49,006 and 45,186 breeding pairs in 2002 and 2009, respectively. They then suggest that their mean estimate of 22,654 breeding pairs in 2018 represents a 50.1% reduction in the population during the past 9 years. However, the amended past population estimates they suggest (49,006 in 2002 and 45,186 in 2009) translate into occupancy rates of approximately 164%. These figures are clearly biologically nonsensical; not only are Flesh-footed Shearwater burrows occupied by just a single breeding pair, but also a large proportion of burrows within any shearwater colony are typically unoccupied in any particular year (burrow occupancy in stable shearwater populations typically ranges from about 45% to 65%). Dyer (2001) assessed burrow occupancy rate for Flesh-footed Shearwaters on Lord Howe Island in 2001 by eliminating all burrows where there was any uncertainty regarding the contents. The resulting estimate—60%— is similar to that obtained in both 2002 (58%) and 2009 (67%).

Lavers et al. (2019) have attempted to justify their erroneous claim of a recent population decline with an unsubstantiated anecdotal observation and an invalid citation. They state that "*Anecdotally, island residents have reported shearwaters moving into new areas, and colony extents increasing in the last decade, but this seems to be accompanied by a reduction in active burrow density (authors personal observations), as occurs when populations are declining* (*e.g.*, Rexer-Huber et al., 2014). Rexer-Huber et al. (2014) examined the effect of different survey methods on population estimates for the Atlantic Petrel *Pterodroma incerta*. The relevance of this citation is puzzling given its authors concluded that (1) the petrel population was not declining, (2) there was no reduction in active burrow density, and (3) the colony was not expanding in area. They stated, *"There is no evidence of a change in Atlantic Petrel burrow density since long-term monitoring was initiated in 2001. While the population currently appears to be stable, our results indicate relatively high interannual variability in burrow density, despite surveys consistently taking place at the same time of year."*

Lavers et al. (2019) continue their argument "*In this extreme scenario, a 5.5% reduction per annum since 2009, the Lord Howe Island Flesh-footed Shearwater population is predicted to decline by 97% in three generations (55 years). Because we cannot assess detection probability retroactively, but we assume it to be lower in 2002 and 2009 than with the EMS2015 burrow scope in 2018, we conclude that the population has declined by an unknown but possibly significant amount in the last decade*." There is, in fact, no evidence to suggest that detection probability has increased as all three surveys used burrowscopes that were fit-for-purpose. Nor is there evidence of a recent decline in the Flesh-footed Shearwater population on Lord Howe Island, let alone one as substantial as that suggested by Lavers et al. (2019).

As Lavers et al. (2019) note in their abstract "*One of the most fundamental aspects of conservation biology is understanding trends in the abundance of species and populations. This influences conservation interventions, threat abatement, and management by implicitly or explicitly setting targets for favourable conservation states, such as an increasing or stable population.*" It is both unfortunate and concerning, therefore, that an unsubstantiated and erroneous declaration of a recent substantial decline in the Flesh-footed Shearwater population on Lord Howe Island is now on the public record. This error presents a false assessment of the effectiveness of conservation action undertaken by the fishing industry to reduce by-catch, and by the Lord Howe Island community to rehabilitate degraded habitat and reduce road-based mortality. Moreover, it could also detract attention and funding away from the plight of other Flesh-footed Shearwater colonies or other seabird species that are actually in decline.

Accordingly, we (the principal authors of previous surveys of Flesh-footed Shearwater on Lord Howe Island) regret not having the opportunity to review the Lavers et al. (2019) paper prior to publication, but appreciate the opportunity now given to us by *Global Ecology and Conservation* to publish this rebuttal.

Declaration of competing interest

Nicholas Carlile, David Priddel, Tim Reid, Peter Fullagar have no conflict of interest in regard to the publication of 'Flesh-footed shearwater decline on Lord Howe: Rebuttal to Lavers et al., 2019' or research carried out on the Flesh-footed shearwater of Lord Howe Island.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://doi.org/10.1016/j.gecco.2019.e00794.

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