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Developing monitoring methods for cryptic species:

A case study of the Australasian bittern, *Botaurus poiciloptilus*.

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degree of

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Abstract

Difficult-to-detect species (here-after, 'cryptic') are problematic to monitor. This is because sampling is often restricted by logistic complications, and species-detectability tends to be low and/or highly variable. Such challenges create data that are complex to interpret, and contain biases that cannot be estimated, making results less meaningful. Yet there is a need to monitor such species as they are also often rare.

In this thesis I review 30 publications, covering 28 different species, to demonstrate that challenges experienced across cryptic species fall into four categories: visually-cryptic, behaviourally-cryptic, spatially-cryptic and temporally-cryptic. The Australasian bittern (*Botaurus poiciloptilus*) is an appropriate case-study for examining the process of developing a monitoring method for cryptic threatened species because they have all four cryptic characteristics. Yet bitterns are also endangered, and what is left of their habitat is under-threat. Currently the most feasible monitoring method available for bitterns is counts of male calls (booms) during the breeding season. However, calling-rate is known to be variable and difficulties in accessing some sites restricts sampling possibilities.

I fitted a range of generalised linear mixed models to 461 15-min call-counts, conducted in a range of conditions, during two breeding seasons at Whangamarino wetland, to identify factors affecting calling-rate-per-individual-bittern (CRPI). Results showed that CRPI was predictable in terms of time-of-day, time-of-year, cloud-cover, rainfall and certain moon parameters, but some spatial and temporal variation remained unexplained. Additionally, I showed that recorders are a cost-effective practical solution to logistical constraints restricting sampling possibilities at some sites. Furthermore, I show that abundance can be estimated from calling-rate by correcting for effect sizes of factors affecting CRPI. Results obtained using 269 15-min sound-files at two sites (Whangamarino wetland and Lake Whatumā) show that these abundance derivations are accurate but imprecise. To understand more about how call-based methods can be used to monitor bitterns, I radio-tracked six males throughout the optimum monitoring-period to confirm that these birds have high site-fidelity, therefore, validating territory-mapping method assumptions. The approach used in this thesis is applicable to any cryptic species, as illustrated with the Guam rail (*Gallirallus owstoni*) in my final discussion.

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