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*Point-of-View*

# A comment on the limitations of UAVS in wildlife research – the example of colonial nesting waterbirds

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## Introduction

Monitoring bird populations is critical in assessing the impacts of conservation and management practices (Kushlan 1993, Frederick et al. 2009, Kingsford and Porter 2009). In particular, waterbird populations are often used as ecological indicators of environmental health (Kingsford 1999, Ogden et al. 2014). Measures of waterbird breeding (e.g., number of nests, eggs, young) can provide detailed data on success and recruitment of waterbird populations and the associated influences of biotic and abiotic factors (Powell and Powell 1986, Robinson et al. 1995, Rodríguez and Bustamante 2003, Brandis et al. 2011). Such information requires high temporal and spatial resolution to identify changes to reproductive success and potential causes (e.g. habitat loss, climate change, flooding patterns) which influence breeding success of colonially nesting birds.

Monitoring of colonial waterbird breeding at a large spatial scale has traditionally been done using aerial surveys (Kingsford and Porter 2009, Chabot et al. 2015) with trained observers (Kingsford and Porter 2009), or by manually investigating images taken by cameras from manned aircraft (Buckland et al. 2012) or unmanned flying-devices (Fraser et al. 1999). Detailed reproductive success data from repeated nest visits or using remote cameras of a sample of nests can provide necessary high temporal frequency data (Brandis et al. 2014).

Recently, unmanned aerial vehicles (hereafter: UAVs) have provided an affordable, versatile, and efficient tool in ecological studies (Koh and Wich 2012, Vas et al. 2015, Chabot and Bird 2016, Hodgson et al. 2016). Indeed, growing literature has shown the validity of using drones to assess colony dynamics and population estimates of breeding bird colonies (McEvoy et al. 2016, Hodgson et al. 2018). Current research into UAVs spans ethical guidelines (Vas et al. 2015), recreating environmental data input from bird flight paths (Rodríguez et al. 2012), monitoring nesting status (Weissensteiner et al. 2015, Junda et al. 2015), and both manual and automated detection routines for groups of birds and nest counts (Trathan 2004, Chabot and Bird

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2013, Sardà-Palomera et al. 2012, Chabot and Francis 2016, Hodgson et al. 2016). However, understanding of interactions between birds and UAVs remains relatively poor, particularly with regards to any potential negative impacts of UAV research for monitoring colonially breeding waterbirds. There is currently limited literature on how interactions with breeding birds or even raptors might change over time, but there is some evidence that breeding birds may become stressed by UAVs (Weimerskirch et al. 2018).

In particular, we respond to a recent paper published in the Journal of Avian Biology (Sardà-Palomera et al. 2017). We agree with the authors that UAVs can 'unravel spatial and temporal factors' associated with colonially nesting birds, and ultimately acknowledge the benefits of UAVs to wildlife research. However, we caution that detailed nesting success can't be adequately measured, as defined by Sardà-Palomera et al. (2017). Importantly, we highlight the necessity for on-ground data collection, concomitantly conducted with UAV data. We draw on our own experience of using UAVs to measure large (~15 000–100 000 breeding pairs) wading bird colonies in arid Australia (Lyons et al. 2018), as well as our experience of colonial wading bird nest success measurement (Brandis et al. 2011, 2014). We conclude with some brief comments on considerations of UAV use in wildlife research, more broadly.

## Limitations of UAVS in measuring detailed nesting success of colonial nesting birds

Sardà-Palomera et al. (2017) used a UAV to measure spatial and temporal factors associated with a small (359 nests) black-headed gull *Chroicocephalus ridibundus* breeding colony in Spain. In addition, they estimated the number of breeding pairs and hatching success and commented on the efficacy of UAVs for monitoring breeding colonies over time.

In the abstract, the authors claim to provide 'detailed nesting success…'; but this definition of nesting success is limited. In their analysis, they distinguished between 'confirmed' nests and 'possible' nests. A nest was considered confirmed if the nest persisted for at least two consecutive weeks. It then followed that breeding success was measured by defining a nest that was detected for three or more consecutive weeks as 'potentially successful nests, in which the eggs may have hatched.' Thirty-four percent of the nests reached the hatching stage, while the remainder did not extend pass the incubation period.

Nest success is usually separated into 5 stages (Mayfield 1975): '(1) survival during the building of the nest; (2) survival during the egg-laying period; (3) survival during incubation; (4) hatching of eggs, which is assumed to take place at a point in time when the first young bird breaks free of the shell; (5) survival of young to fledging.' Sardà-Palomera et al. (2017) measured the proportion of nests that produce offspring, where adults attended, but even 'confirmed' nests did not adequately measure success as no juveniles were observed. The 'confirmed' nests from UAV data inadequately measured hatching success. Black-headed gulls *Chroicocephalus ridibundus*, as with many colonially nesting waterbird species, can lay up to three (or more) eggs in a clutch (Goodbody 1955). One out of three eggs could have survived in a nest: 33% success which would diverge complete success if an adult was in attendance (Sardà-Palomera et al. 2017). Also, black-headed gulls can lose a clutch and re-lay in about 10 d (Weidmann 1956), resulting in a secondary peak of breeding, preceded by a peak of egg losses (Patterson 1965). Only the first breeding attempts per location were included in the Sardà-Palomera et al. (2017) study.

These assumptions could result in a very different understanding of the nesting success rate of the colony than what may actually be occurring. Such inaccurate assessments may lead to inadequate management actions which affects conservation. Ultimately, in order to fully understand the dynamics of nesting success within a colony (i.e., all the stages: Mayfield 1975), on-ground research is currently necessary to support interpretations of data gathered with UAVs of breeding success. We note that UAV data on breeding events of colonial nesting birds offers a promising future and a potentially cost-effective approach to collecting more data than was previously possible (Anderson and Gaston 2013, Weimerskirch et al. 2018, Hodgson et al. 2018), but UAV monitoring is a complementary tool, rather than an alternative approach to detailed on-ground surveys.

We use UAVs across a wide range of environments in central and eastern Australia (Lyons et al. 2018), including monitoring of colonies of waterbirds (ranging in size from ~15 000–100 000 breeding pairs, predominantly Straw-necked Ibis *Threskiornis spinicollis* and some Australian White Ibis *T. moluccus*). UAVs have allowed delineation of the extent of the colonies (i.e., the overall spatial size and number of birds), previously exceedingly difficult to estimate accurately with traditional methods. We also used on-ground visits to investigate detailed nesting success. UAVs can be successfully used to assess colony sizes, nesting stage, and numbers of birds (Sardà-Palomera et al. 2012, Hodgson et al. 2018) but reproductive behaviour and metrics (i.e., clutch sizes, hatching rates, and fledging rates) require on-ground monitoring. UAVs will continue to become an increasingly powerful methodology for monitoring colonially nesting waterbirds.

## UAVS in wildlife research

UAVs have a cost, like all surveys (see supplementary table by Roelfsema et al. 2015 for a summary). Training is required along with time and financial costs associated with certification and permits. Data collection takes time, affected by limitations on the conditions for collection of useful UAV data; rain or high wind, and often low sun angles (early morning and late afternoon) produce images with too much shadow to delineate targets of interest. There are also possible hardware and software malfunctions. Finally, UAV image processing can take significant amounts of time post-field, impacting on the time-lag (days to weeks) between UAV data collection and outputs.

Comparisons of 'UAVs vs humans' can make attractive sound bites (Hodgson et al. 2018) and superficially treat the process of humans still counting objects from UAV imagery, or producing image classifiers. Data from UAVs are not a panacea for surveys, often requiring on-ground supportive data, to ensure that advice for management is not misplaced and affects conservation outcomes.

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