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SHORT COMMUNICATION

Estimating production in ducks: a comparison between ground surveys and unmanned aircraft surveys

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Abstract

We tested the use of unmanned aerial systems (UAS) in duck brood surveys in boreal wetlands in Finland. We performed brood surveys at the same wetlands concurrently with ground-based point counts and using a UAS (multicopter; drone counts) equipped with a camera that produced high-quality images for identification of broods and ducklings. The number of broods did not differ between point counts and drone counts in three duck species, the mallard (*Anas platyrhynchos*), common teal (*Anas crecca*), and common goldeneye (*Bucephala clangula*). The number of ducklings was higher in drone counts than in point counts in the common teal, but no such difference was found in the mallard and common goldeneye. UAS-based images seem to be useful for estimating numbers of both broods and ducklings for different duck species, although the manual processing of images is labor intensive.

Keywords Brood size · Drone · Multicopter · Species detection · Waterbird census

Introduction

Information on animal abundance and production is of crucial importance not only for studying population dynamics but also for wildlife managers to adjust harvest at sustainable level and to assess the success of different management actions. Considering birds, annual production is often estimated with ground surveys in which individuals of target species are counted from fixed vantage points (e.g., Koskimies and Pöysä 1991; Pöysä 1998). However, rich vegetation may obscure visibility, resulting in underestimation of production. This is often the case with waterbird brood surveys. For example, Pagano et al. (2014) estimated in a study area in the North American Prairies that traditional roadside duck brood surveys detected only 30–45% of the available dabbling duck broods.

Recently, unmanned aerial systems (UAS) have been increasingly used for gathering data in wildlife monitoring and research (Linchant et al. 2015; Christie et al. 2016; Mulero-Pázmány et al. 2017). While UAS have been used to survey in particular many large terrestrial mammals, aquatic animals, and birds, comparisons with results of other survey methods in free-ranging animals are limited (Linchant et al. 2015). Considering birds, UAS have been used mainly for colonial species in which aggregations of breeding individuals or nests have been surveyed with both UAS-based and ground-based direct surveys and results have been compared (see Chabot et al. 2015; Linchant et al. 2015; Hodgson et al. 2016; Brisson-Curadeau et al. 2017). The focus has been in single species colonies the location of which was known beforehand. Feasibility of UAS for monitoring and gathering data of species with a more scattered distribution of individuals is less obvious and has not been assessed (but see Chabot and Francis 2016; McEvoy et al. 2016).

Here, we tested the feasibility of multicopter drone use in duck brood surveys in boreal wetlands, in particular whether they could provide a tool to increase the reliability of ground-based brood surveys. We performed brood surveys at the same wetlands concurrently with ground-based point counts and an UAS equipped with a camera that produced high-quality images for identification of broods and ducklings.

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Material and methods

We performed ground-based waterbird point counts and UAS-based counts at 17 sites in Maaninka (63° N, 27° E), central Finland, during the brood rearing season in 2017. The sites represented typical eutrophic boreal lakes with wide stands of emergent vegetation (Table S1 in the electronic supplementary material). At each study site, a survey area (1.2–8.8 ha) including open water, shoreline, and stands of emergent vegetation was predefined, and a fixed vantage point (two vantage points at one wetland) for point count was selected. Duck broods were surveyed from the fixed point(s) using the standard waterfowl point count method (Koskimies and Pöysä 1991). Immediately after the point count, an aerial survey of duck broods was done with the UAS at each site (hereafter, drone count). The point count and drone count covered the whole survey area at each study site, although inner parts of the stands of emergent vegetation were not equally visible in the point count. The brood surveys were repeated three times at each site during the summer, except two sites that were surveyed only in the middle period (see Table S1 in electronic supplementary material for details of the dates and timing of the surveys for each site and survey period).

The UAS platform used in this study was a DJI Matrice-quadcopter equipped with a gimbaled downward-pointing camera, model DJI X5 (530 g). The UAS was powered by a 5700-mAh rechargeable lithium-polymer battery, which is able to provide up to 20 min of flight endurance at an airspeed of ~ 60 km/h, depending mostly on wind and temperature conditions. The payload capacity of the UAS, with a diagonal wheelbase of 650 mm, was about 2300 g, which included the battery (676 g). In large study areas (over 5 ha), battery replacement was done during the survey. In this study, total flight time for a survey was 5–27 min, including battery replacement when needed. The UAS was controlled by a tablet computer and using the software DJI GO (DJI), which allowed for completely automated flights, including take-off and landing. The automatic survey flights (transects) were designed using Map Pilot (MME). The operator of a small drone with visual contact and flying altitude below 150 m does not require a special permission in Finland.

In each survey, the UAS was operated from a vantage point 200–1000 m from the survey area to avoid disturbance, and allowed to fly back and forth at an altitude of 40 m along the pre-programmed transects (see Fig. 1 for an example). The transects covered the whole survey area, including all open water and areas covered by emergent vegetation. Photographs were taken at 1–2-s intervals and the transects (200–900 m long) were photographed in 36–170 geotagged images (mean size 6.2 megapixels on the disk) per site, producing about 4600 still images in all. To acquire sufficient image overlap for processing, transects were typically 25 m apart. The camera was triggered at distance intervals to attain 60% front-lap and 60% side-lap. Flight speed varied from 2 to 6 m/s depending on weather conditions. Camera shutter speed was typically faster than 1/500 s, ISO was 100, aperture was f 1.7, and focus of lens (15 mm) was set at infinity. To minimize vibration blur effect in images, flights were not carried out during wind conditions over 8–9 m/s.

Waterbirds from each image were counted manually on a desktop computer with a high-resolution monitor by one

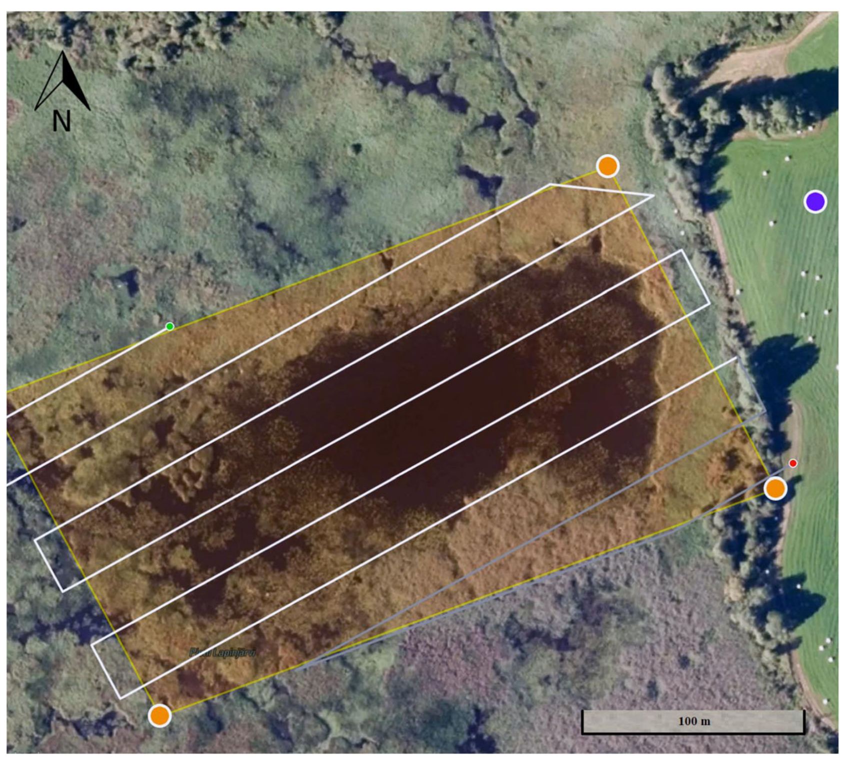

Fig. 1 An example of predefined drone flying routes in one of the waterbird study sites, Pieni Lapinjärvi. The UAS was operated from a vantage point in a field (large blue dot in the upper-right corner of the image); brood point count was done at the same point. Starting point (small red dot in the easternmost corner of the survey area), predefined flying route (white line), and ending point (small green dot in the northwestern part of the survey area) of the drone count are also given

experienced person (Juho Kotilainen). Species and age class of broods (according to Pirkola and Högmander 1974) were identified by size, shape, and color of individuals. Special attention was paid to not count the same individuals twice; the location of individuals between adjacent images was compared and the difference in time between the images was considered. An overall survey was first made of the images and all noticeable broods were counted. Shoreline, small islands, emergent vegetation, and other places presumably having broods were checked with a zoomed view. The time needed to complete the count of images from one survey area (35–170 images per area and survey) ranged from 15 to 75 min.

We used a paired Wilcoxon signed-rank test for comparisons of the numbers of broods and ducklings between point and drone counts. The tests were based on site-specific mean values calculated over the three survey periods; only sites for which a brood was observed either in point count or drone count in at least one survey period were included for each species.

Results and discussion

In total, 22 dabbling duck (*Anas* spp.) broods were observed in point counts and 18 broods in drone counts, the corresponding figures being 19 and 17, respectively, for the common goldeneye (*Bucephala clangula*; hereafter, goldeneye), the only diving duck species observed in the surveys. The total number of dabbling duck ducklings was 109 in point counts and 141 in drone counts, the total number of common goldeneye ducklings being 135 and 180, respectively. The mallard (*Anas platyrhynchos*) and common teal (*A. crecca*; hereafter, teal) were the most numerous dabbling duck species, making together 86.2% of broods and 89.0% of ducklings observed in point counts, the corresponding percentages being 94.5% and 99.3%, respectively, for drone counts. Here, we focus on the three most numerous species, the mallard, teal, and goldeneye.

The data included altogether 47 site-survey period cases. In a majority of cases, and for each species, no broods were observed in either of the counts while the number of broods observed varied depending on species, count, and survey period (Fig. S1 in the electronic supplementary material). Considering only cases in which a brood was observed in either of the counts, no difference was found in the number of broods observed between point counts and drone counts for any species (Table 1). The number of ducklings observed in drone counts was higher than that in point counts in the teal, but no difference between point counts and drone counts was found in the mallard and goldeneye (Table 1).

The high proportion of cases in which no broods were observed in either of the counts was not totally unexpected. Summer 2017 was the poorest breeding seasons of mallard, teal, and goldeneye during the history (1988–2017) of monitoring waterfowl production in Finland (Natural Resources Institute Finland, unpublished data). The timing of spring thaw was exceptionally late and weather conditions in June and July were not favorable to newly hatched ducklings,

Table 1 The number of broods and the number of ducklings observed per site in point counts and drone counts for three duck species. Only sites in which a brood was observed either in point count or in drone count during at least one survey period are included for each species (mallard, $n = 6$; teal, $n = 8$; goldeneye, $n = 4$). Values are means calculated for each site over the three survey periods. Wilcoxon signed-rank test statistics for paired comparisons are given

Mallard		Point count	Drone count	*Z*	*p*
Number of broods	Mean	0.7	0.5		
	Median	1.0	0.5	0.447	0.655
	Range	0–1.0	0–1.0		
Number of ducklings	Mean	4.6	3.7		
	Median	6.0	2.5	0.271	0.786
	Range	0–8.0	0–10.0		
Teal					
Number of broods	Mean	0.8	0.9		
	Median	0.8	1.0	0.172	0.863
	Range	0–2.0	0–1.6		
Number of ducklings	Mean	3.1	7.1		
	Median	2.0	5.8	2.103	0.035
	Range	0–7.0	0–16.3		
Goldeneye					
Number of broods	Mean	2.1	1.6		
	Median	1.0	0.8	1.604	0.109
	Range	1.0–5.3	0–5.0		
Number of ducklings	Mean	12.3	16.8		
	Median	3.8	6.5	1.095	0.273
	Range	0–41.7	0–54.0		

probably increasing duckling mortality (H. Pöysä, unpublished data). High proportions of lakes without broods have also been observed in detailed local studies in boreal breeding areas of ducks (e.g., Sjöberg et al. 2000). Lakes that consistently do not have duck broods probably are of low-quality brood habitats, particularly in terms of food abundance (Sjöberg et al. 2000; Gunnarsson et al. 2004). It is possible that some of the more sparsely vegetated lakes in our data have a shortage of invertebrate food needed by ducklings and therefore did not have duck broods during the study summer.

Our results suggest that UAS are a feasible tool for conducting duck brood surveys, but it requires development and testing to be a cost-effective alternative for traditional ground-based brood counts in boreal lakes. UAS surveys are relatively time consuming as compared to traditional ground-based point counts; in particular, manual counting of individuals afterwards from the images is laborious. Providing that image resolution is sufficient, automated image detection would greatly reduce the time needed for data processing (see Chabot and Francis 2016). In addition, as our comparisons indicate, the probability of detecting duck broods may not be higher in UAS-based counts than in ground-based counts, although UAS-based counts seem to provide higher estimates of the number of ducklings. Duck broods often move near the edge of emergent vegetation and some ducklings swimming among the vegetation may remain undetected in a ground-based census. If emergent vegetation is limiting visibility in UAS-based counts, it is possible to calculate a detection coefficient similar to that calculated by Barasona et al. (2014) for canopy cover in order to correct the reduction of visibility. The use of thermal camera might also increase detection probability in conditions where temperature contrast is high (e.g., Mulero- Pázmány et al. 2014). Finally, although individuals of different species clearly responded to the flying drone (V.-M. Väänänen et al., unpublished data), we did not observe a large-scale and consistent disturbance effect in waterbirds, which is in accordance with earlier works (Chabot et al. 2015; Vas et al. 2015; Brisson-Curadeau et al. 2017).

In conclusion, UAS-based images proved to be useful for estimating numbers of both broods and ducklings for different duck species. We encourage additional field tests of the feasibility of UASs in duck brood surveys in different types of wetlands and additional comparisons between UAS-based and other survey methods in order to verify and calibrate ground-based counts.

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