

The use of small UAVs in precision agriculture and their impact on the environment and birds

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Abstract. This study focuses on the impact on birds and the environment of using small unmanned aerial vehicles (UAVs) or drones for the needs of precision agriculture. For the period 2019-2025, 385 flights were carried out over agricultural areas in the region of Southern Dobruja, Republic of Bulgaria. Many of the flights were carried out 100m above the field at a speed of 10m/s along a meandering trajectory. The conducted studies found that no disturbance was observed on the part of the flying or nesting birds. Only one case of an attack attempt by a bird of prey was observed, but there was no collision. The measured noise pollution shows very low levels. The study proves that small quadcopter-type UAVs are an indispensable assistant to farmers, and no impact on the environment was recorded during the study.

Key words: UAV (unmanned aerial vehicle), precision agriculture, remote sensing, ecology, birds.

Introduction

Technological developments have created increasingly accessible and functional small unmanned aerial vehicles (UAVs) or drones. They are increasingly used for monitoring agricultural areas (Atanasov, 2024). These devices provide invaluable information and are a key element of precision agriculture, but there is still little information about how they affect the environment. Despite their widespread use, their impact on birds and the environment in which they fly is still poorly studied. Different types of UAVs have different characteristics and can leave a specific mark on the environment in which they are used. These features related to the region and the type of device are the subject of various studies. There are studies that illustrate that UAVs can reduce disturbance to birds compared to traditional methods of monitoring agricultural areas (Brisson-Curadeau et al., 2025). Vas et al. (2015) describe an experiment according to which it is possible to get as close as 4 m to mallards (*Anas platyrhynchos*) and common greenshanks (*Tringa nebularia*) before

they exhibited disturbance. According to the study, vertical approach scares birds more. Long-distance flying is recommended. A similar study (Cantu de Leija et al., 2023) reports little effect on nesting birds when flying more than 50 m and none on ground-nesting birds.

The specificity of agricultural areas is the almost complete absence of ground-nesting birds in fields with agricultural crops due to intensive cultivation. In these areas, nesting is possible in the groves (if any) and in areas with trees where birds are expected to be in the crown.

Drones can also be perceived as a threat by various birds, associating them with flying predators (Egan et al., 2020; Mapes et al., 2020). They can also be recognized as prey by birds of prey, which strongly depends on the size, type and speed and trajectory of flight. Studies on the response of different types of UAVs demonstrate a wide range of behavioural responses, influenced by the species studied, the type of drone and the specifics of the flight (Polensky et al., 2022; Rümmler et al., 2021; McEvoy et al., 2016; Lyons et al., 2018).

In the study by Brisson-Curadeau et al. (2025) the reaction to a flying quadcopter by small birds at a distance of 70 m, for medium-sized birds of 50 m and large birds of 30 m at a flying speed of 10 km/h was confirmed. It was concluded that flying at a higher speed of 60 km/h on average caused more reactions than slower drones (these are UAVs with rotor wings at a speed of about 10 km/h), probably because higher speeds are usually associated with predatory attacks (Egan et al., 2020).

The increasingly advanced UAVs with rotor wings (quadcopter type) and the various types of multispectral cameras mounted on them make them an indispensable assistant for agricultural producers. They fly faster and faster, and do not need a runway. Their effect on birds still needs to be studied.

The aim of the study is to monitor the impact on the environment and birds of the use of small UAVs such as quadcopters used for the needs of precision agriculture. To achieve the aim, the following tasks have been formulated: 1) study the impact of the use of UAVs on birds; 2) measure the footprint of the use of UAVs on the environment.

Materials and methods

Study site

Dobruja is a historical and geographical region in Northeastern Bulgaria, covering an area of over 23,000 km². The region is a plateau with a slightly hilly relief. Slightly leached and carbonate

black soils predominate. Dobruja is primarily an agricultural region, which is why a large part of the territory is occupied by arable land. The region is mainly engaged in the production of cereals, which also determines the presence of large arable areas.

In southern Dobruja, Field Protection Forest Belts have been planted, which are artificially created forest plantations to combat wind and water erosion, drought and dry winds. The main ones (width up to 20 m) are located perpendicular to the prevailing winds, at a distance of 500 m, and the secondary ones (width up to 16 m) - transverse to the main ones, at a distance of 1000 m. The current average height of the belts is about 18 - 20 m. The fields between them are arable land. These artificially condemned forest strips are the habitat of the birds in the area.

UAVs parameters

Two UAVs were used for testing, these are: DJI Mavic 2 pro weighing 907 grams and DJI Phantom 4 weighing 1388 grams (DJI, 2025) (Fig. 1). All flights were carried out in southern Dobruja during the period 2019 - 2025 for the study of agricultural crops. The flights were carried out at an altitude above the terrain from 35 to 120 m. The total number of flights for the period is 385, all of which were carried out over agricultural areas, with 90% of them being carried out at an altitude of 100 m.



Fig. 1. Photo of DJI Mavic 2 Pro (left) and DJI Phantom 4 (right).

The UAV control is dual-band with operating frequencies of 2.400 – 2.483 GHz and 5.725 – 5.850 GHz. Both devices have a horizontal speed: up to 72 km/h in Sport mode. Vertical speed: Up to 6 m/s in Sport mode. Range: 5 km. When carrying out the studies, the flight was set to “p” mode, which limits the speed to 10 m/s.

The flight missions are planned with the software products PIX4Dcapture (Pix4D, 2025) and DroneDeploy (DroneDeploy, 2025). The flight mission is planned along a meander-shaped route with a set overlap of the images in length and width of 70 to 80%. The flight time depends on the shooting area and the flight altitude. The standard shooting time is about 18 minutes. This time is strongly influenced by the speed and gusts of wind. It has been established that flights should not be conducted at wind speeds greater than 10 m/s. Winds with such values are not an exception in the area. In case of gusts with a higher speed, the UAV cannot complete the flight mission, and an emergency landing must be made.

Remote spectral measurement studies the amount of light reflected from the object of study, but due to the variability of the intensity of solar radiation, the amount reflected also changes and a correction needs to be made. Different absorption and scattering in the individual spectral bands of the atmospheric composition would affect the obtained indices. Especially in low light conditions and difficult to distinguish the spectra. To compensate for this drawback, a measurement of the total illumination is necessary.

To measure the illumination, a Hopoocolor HPCS-320 spectral analyser (Fig. 2) was used, with a high-precision CCD optical sensor. Wavelength Range: 380 to 780 nm (Hopoocolor, 2025).

An important parameter for the accuracy of the information received is the parameter Ra (CRI - colour rendering index) reflecting the effect of the lighting fixture on the colour of the illuminated objects. With a high index, we have a guarantee of good recognition of each frequency band.

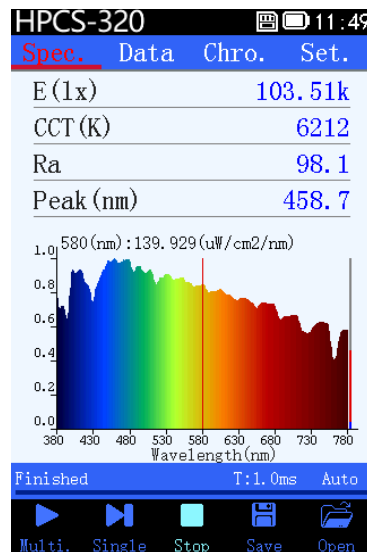


Fig. 2. HPCS320 spectrometer.

Results and Discussion

During the surveys, light characteristics were measured. The results for the 2022-2023 season are shown in Table 1.

An important parameter is Ra for the correct determination of colour. At values above 80 we have true colour perception; in this case all measurements have values above 97. Due to the requirements for diagnostics of agricultural areas, the surveys were conducted between 11 am and 2 pm.

This is the period in which the sun is almost vertically above the field.

Influence of flights on birds

The DJI Mavic 2 pro UAV is grey in colour and from a distance resembles a bird. The DJI Phantom 4 pro is white in colour and its shape does not resemble a bird. It is also a little noisier, which would confuse and discourage birds of prey (Fig. 3).

Table 1. Characteristics of light when shooting.

Date	E - illumination (lx)	Peak (nm)	Colour temperature CCT (K)	Ra
9.12.2022	20 670	458.7	6511	97.3
22.12.2022	42 670	479.9	5688	98.5
20.1.2023	28 890	479.9	5725	97.0
24.2.2023	32 630	458.7	6492	97.8
21.3.2023	50 160	458.7	6307	97.7
25.3.2023	83 380	458.7	6148	98.3
9.4.2023	103 900	459.7	6063	98.2
14.4.2023	61 920	458.7	6238	98.2
23.4.2023	92 640	458.7	5999	98.2
30.4.2023	106 960	458.7	6142	98.2
5.5.2023	46 710	400.7	6852	98.4
12.5.2023	67 150	458.7	6425	98.7
19.5.2023	123 920	472.8	5817	98.8
1.6.2023	108 040	472.8	5980	98.4
8.6.2023	112 990	458.7	6105	98.5
15.6.2023	122 300	459.7	6119	98.3
22.6.2023	31 520	401.7	7244	98.3
29.6.2023	113 560	458.7	6056	98.5

**Fig. 3.** Visual comparison of a flock of pigeons and photos of the DJI Mavic 2 Pro and DJI Phantom 4 Pro in flight.

In all experimental flights, there were two cases of interest from birds of prey in the aircraft. In the first case, when filming a corn field in early August, a saker falcon (*Falco cherrug*) swooped down on the drone, but stopped its attack a meter from the drone and did not make contact with it. The UAV was in takeoff mode about 30 m above the field. The specific hum of the UAV probably discouraged the bird. In the second case, while surveying a winter wheat crop at 100 m above the field on June 5, a pair of Eurasian goshawks (*Astur gentilis*) circled the drone during a mission but did not attack. It is believed that the unusual buzzing

and extremely straight flight path of the Phantom 4 discouraged the birds.

It has been observed that most birds (swallows, crows) bypassed the drone without paying attention to it. In the region of southern Dobruja, the fields are separated by field protection belts along which birds' nest. The flights to photograph wheat, corn and sunflower crops were carried out at a height of 100 m above the terrain due to the need to photograph a large area. Typically, these tree lines are no higher than about 10 m, which in turn provides about 90 m of distance between the UAV flying along a horizontal meandering trajec-

tory and the birds in the trees. No anxiety behaviour of the birds in the treetops was observed during the flights. This confirms the findings of Vas et al. (2015).

Ecological features

The received noise level 1 m from the UAV when taking off was using the aircraft was measured 1 meter 76.3 dB (Fig. 4a). The received noise level at 50 m from the in-flight UAV was 46.3 dB (Fig. 4b), which was less than the ambient noise. The noise meter used was the UNI-T UT353 (UNI-T,

2025) with a sound intensity measurement accuracy of ± 1.5 dB, Frequency response 31.5 Hz-8 kHz.

Freezing

DJI Phantom 4 is powered by a lithium-polymer battery (model PH4-5670mAh-15.2V at 89.2Wh) which provides a flight time of 30 min depending on wind speed. For DJI Mavic 2 Pro, a lithium-polymer battery (model JMA2-3850mAh-15.2V at 59.29Wh) is used providing up to 31 min of flight time. Both models do not use an internal combustion engine and fossil fuels. This means that they do not pollute the environment.

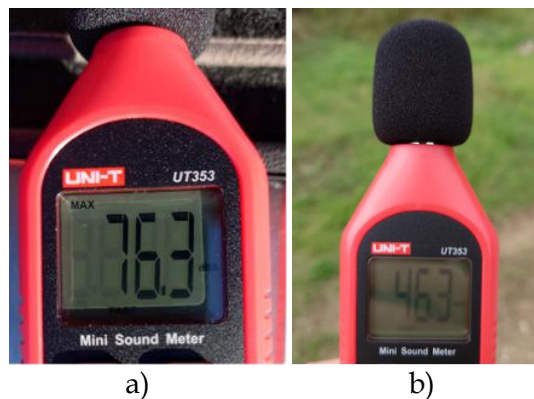


Fig. 4. Measured received noise levels at 1 m (a) and 50 m (b) from the UAV.

The colours

The DJI Phantom 4 is white and when flying with clouds of the corresponding colour, it becomes difficult to see at more than 300 m, despite the open spaces above agricultural areas. According to the regulation for controlling UAVs, the pilot is obliged to maintain visual contact throughout the flight. On the other hand, the DJI Mavic 2 pro is grey and at greater distances or in dark clouds it becomes difficult to notice. Limiting the flight area would reduce the area that can be photographed

in one flight. It is advisable to choose a UAV with bright colours that are not found in nature, in order to make visual contact easier and not to show interest to birds of prey. The bright colour would also help in the event of an emergency landing in the monitored field for easier detection of the UAV. In Fig. 5 is shown a photo of DJI Phantom 4 at 150 m from the operator. In the photo there are 2 drones, one is in white and the other in red. Despite the distance, the visibility of the brighter colour is better.

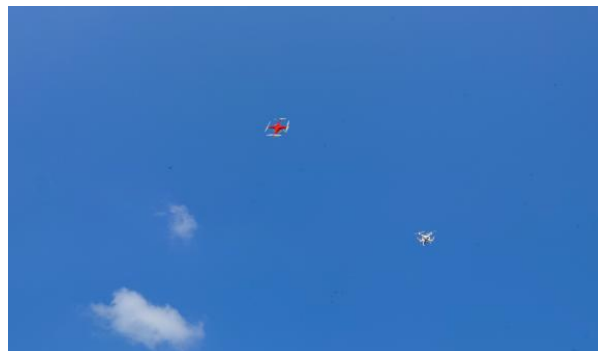


Fig. 5. DJI Phantom 4, 150 m from the operator in white and red.

Conclusions

The study about the influence of small drones on the reaction of birds to them, conducted on the territory of southern Dobruja, gave the following results:

1) No concern was observed from the birds regarding the flight of the UAVs. As a standard, it moved horizontally over the observed field at a constant speed at an altitude of 100 m.

2) Only one attempt to attack the drone was observed from the birds of prey. It is assumed that the specific buzzing repelled the bird.

3) Birds passing by the UAV in flight did not show any interest or concern due to the uniform flight and trajectory during the filming.

4) The UAV does not have any ecological impacts on the environment. There is no noise pollution. It also does not use fossil fuels and does not emit harmful emissions.

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