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A study on the possibilities of using unmanned aerial vehicles (UAVs) in an ecological pig farm

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Abstract. The "Mangalitsa" breed is well known with its best meat quality and simple way of breeding. Unfortunately, since the middle of the last century it disappears as a genetic resource in Bulgaria. Today, the breed is being bred again, but no research has ever been done on their behavior and habits. In this study, we examine the possibilities of effective research on pigs' behavior, and determine the habits and spatial distribution of groups of Mangalitsa pigs through new technologies for remote sense monitoring. A DJI drone, model Mavic Air, was used, equipped with various visualization sensors in order to optimize the results.

Key words: behavior, drones, Mangalitsa, multispectral images, pigs, UAVs.

Introduction

Unmanned aerial vehicles (UAVs), in short "drones", have been used for nearly a century in many fields of development - scientific research, industrial, agricultural, etc. The applications of these devices are undisputed in remote observations of the environment - natural phenomena with high spatial and temporal resolution (Di Felice et al., 2018), discovery of various plant and animal species in hard-to-reach areas (Yordanov & Mollov, 2022), in the field of agriculture to develop and assess the growth of various crop types and water resource management (Allen et al., 2011; Anderson et al., 2012; Kogan, 2001; National Geospatial Advisory Committee, 2012; Walker, 2011). The examples of the usefulness of drones are endless, and every day new possibilities of application are discovered. With the increasing progress and variety of sensors the drone can be equipped with, better resolution is achieved when observing the area or object of interest.

Nowadays, remote sensing with unmanned aerial vehicles is becoming one of the most powerful and reliable ways to collect data from wildlife, in the work of ecologists, conservationists and behavioral scientists (Anderson & Gaston, 2013; Chabot & Bird, 2015; Koh & Wich, 2012). There are many publications concerning tracking animals and their habitats without risk for the humans (Christie et al., 2016; Linchant et al., 2015), researching behavior and habits in different groups of animals (Hodgson et al., 2013; Vermeulen et al., 2013; Yordanov & Mollov, 2022). Since drones can directly affect the behavior of many birds and mammals, they are also one of the factors to track (Mulero-Pázmány et al., 2017; Schad & Fischer, 2022).

Here we consider the applicability of a drone, model "DJI Mavic Air", equipped with various visual tools, to study the behavior, habitat and assessment of morpho-physiological parameters of Mangalitsa pigs.

According to the studies, the probability of locating and describing pigs from aerial photography is highly dependent on the time of the survey. As the probability is lowest in the mid-afternoon and correspondingly highest in the evening (Duffy et al., 2018; Hvala et al., 2023). This is a consequence of the position of the sun and reflections from the Earth's surface.

Materials and methods

The aim of the study was to observe the possibilities of UAVs in an ecological pig farm. The observed animals have been grown outdoors in a farm located in the territory of the village of Banya, Razlog municipality. The habitat is surrounded by low fences and an electric shepherd, with approximately 70% open area and the other 30% forest vegetation.

For the purposes of the study, a DJI Mavic Air drone with a standard RGB camera was used. The technical characteristics of the drone and camera are presented in Table 1.

The drone is small and very maneuverable. Despite its light weight, an additional multispectral camera is attached to it, which reduces the flight time from 21 to 15 minutes.

Table 1. DJI Mavic Air specifications (www.dji.com).

AIRCRAFT		CAMERA	
Takeoff Weight	430 g	Sensor	1/2.3” CMOS Effective Pixels: 12 MP
Dimensions	Folded: 168×83×49 mm (L×W×H) Unfolded: 168×184×64 mm (L×W×H)	Lens	FOV: 85° 35 mm Format Equivalent: 24 mm Aperture: f/2.8 Shooting Range: 0.5 m to ∞
Diagonal Distance	213 mm	ISO Range	Video: 100 - 3200 (auto) 100 - 3200 (manual) Photo: 100 - 1600 (auto) 100 - 3200 (manual)
Max Ascent Speed	4 m/s (S - mode[1]) 2 m/s (P - mode) 2 m/s (Wi-Fi mode)	Shutter Speed	Electronic Shutter: 8 - 1/8000s
Max Descent Speed	3 m/s (S - mode[1]) 1.5 m/s (P - mode) 1 m/s (Wi-Fi mode)	Still Image Size	4:3: 4056×3040 16:9: 4056×2280
Max Speed (near sea level, no wind)	68.4 kph (S-mode[1]) 28.8 kph (P - mode) 28.8 kph (Wi-Fi mode)	Still Photography Modes	Single shot HDR Burst shooting: 3/5/7 frames Auto Exposure Bracketing (AEB): 3/5 bracketed frames at 0.7EV Bias Interval: 2/3/5/7/10/15/20/30/60 s Pano: 3×1: 42°×78°, 2048×3712 (W×H) 3×3: 119°×78°, 4096×2688 (W×H) 180°: 251°×88°, 6144×2048 (W×H) Sphere (3×8+1): 8192×4096 (W×H)
Max Service Ceiling Above Sea Level	5000 m	Video Resolution	4K Ultra HD: 3840×2160 24/25/30p 2.7K: 2720×1530 24/25/30/48/50/60p FHD: 1920×1080 24/25/30/48/50/60/120p

			HD: 1280×720 24/25/30/48/50/60/120p
Max Flight Time (no wind)	21 minutes (at a consistent 25 kph)	Max Video Bitrate	100Mbps
Max Hovering Time (no wind)	20 minutes	Supported File System	FAT32
Max Flight Distance (no wind)	10 km	Photo Format	JPEG/DNG (RAW)
Max Wind Speed Resistance	29 - 38 kph	Video Format	MP4/MOV (H.264/MPEG-4 AVC)
GIMBAL			
Mechanical Range	Tilt: -100° to 22° Roll: -30° to 30° Pan: -12° to 12°		
Controllable Range	Tilt: -90° to 0° (default setting) -90° to +17° (extended)		
Stabilization	3-axis (tilt, roll, pan)		
Max Control Speed (tilt)	120°/s		
Angular Vibration Range	±0.005°		

Multispectral cameras have been added to investigate data acquisition efficiency compared to standard equipment. Multispectral cameras from the Mapir company with different spectral ranges of operation were used: 1- RGN (red + green + near infrared) and 2- RE (red edge). The technical characteristics of the cameras are presented in Table 2 (www.mapir.camera).

The flights with the drone and multispectral cameras had been done during the warm months of 2023 and 2024 – June, July, August and September. Remote sense monitoring was carried out every 2-3 weeks, for 2-3 days. The data reporting completed during the daylight hours from 08:00h to 20:00h, with the average frequency of flights being around 15 minutes.

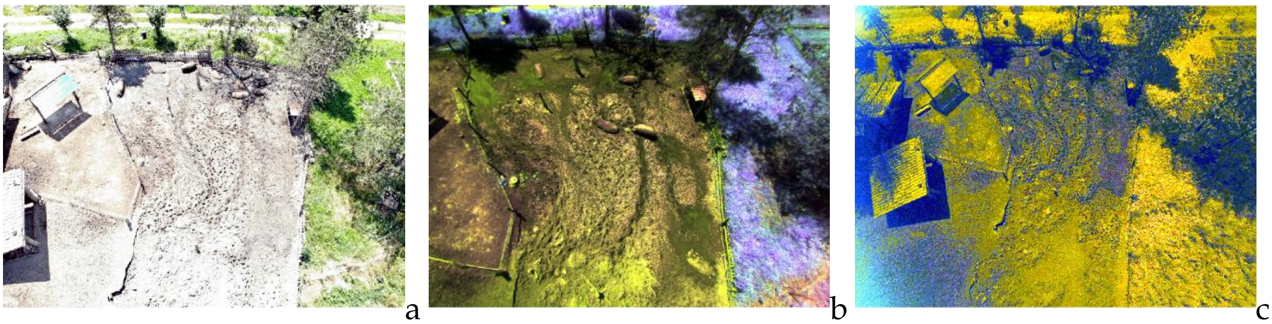
Table 2. Specifications of Mapir Survey 3W RGN and RE cameras.

	RGN	*RE*
Filter Transmission	RGN (Red+Green+NIR): 550nm/660nm/850nm	Red-Edge (RE): 725nm
Image Resolution	12 MegaPixel (4,000 x 3,000 px), 8MP	
Image Format	RAW+JPG, JPG (RAW is 12bit per channel, JPG is 8bit per channel)	
Video Resolution	2160p24, 1440p30, 1080p60, 720p60	
Video Format	MP4 (H.264 Codec)	
Lens Optics	87° HFOV (19mm) f/2.8 Aperture, -1% Extreme Low Distortion (Non-Fisheye) Glass Lens	
Ground Sample Distance (GSD)	5.5 cm/px (2.17in/px) at 120 m (~400 ft) AGL	
Sensor	Sony Exmor R IMX117 12MP (Bayer RGB)	
GPS/GNSS (External)	Standard: u-blox UBX-G7020-KT Advanced V2: u-blox M10	
Capture Speed	RAW+JPG: 2.75 Seconds / Photo. JPG: 1.5 Seconds / Photo	
Weight	50g (1.8 oz) (Without Battery), 76g (2.7 oz) (With Battery)	
Dimensions	59 x 41.5 x 36mm (Length x Height x Depth)	
Operating Temperature	-10°C to 65°C	

Results and Discussion

In the first flight with a drone on 21 June 2023, restlessness and irritation were observed in the animals, which subsided afterwards. As the flight was made in a height range of 5 to 10 meters, the shortening of the distance between the drone and the pigs caused different levels of response in them (Bennitt et al., 2019; Fettermann et al., 2019; Headland et al., 2021; McEvoy et al., 2016; Ramos et al., 2018; Rümmler et al., 2021; Schad & Fischer, 2022; Weimerskirch et al., 2018). The most pronounced restlessness was reported in the piglets, which were 2-3 months old, probably due to Mavic Air's noise (around 76 dB). Pigs are known for their well-developed hearing at the expense of vision (Gonyou, 2001). The sound range of pig hearing extends from 42 Hz to 40.5 kHz (Heffner & Heffner, 1990; Olczak et al., 2023). Studies (Olczak et al., 2023; Talling et al., 1996) show that piglets have stronger and longer responses when exposed to intense and higher frequency sound. This is also the reason why they reacted sharply when the drone appeared, even before they saw it. While the response of older animals is more likely to be triggered by a sudden change in the background noise of the habitat (Bennitt et al., 2019; Rümmler et al., 2021; Schad & Fischer, 2022; Schroeder et al., 2020; Weimerskirch et al., 2018). Therefore, the flights have been done in at an interval of 20-30 minutes to give the pigs time to calm down. On the second day of observation, the animals were calmer and did not react to the presence of the drone, and on the third day, even the piglets did not notice its presence. This allowed a descent in height and a hover of 2 meters. During the rest of the reporting period from July 2023 to September 2024, all flights for the purpose of surveying animal behavior were made at a height of 2 meters. The time interval between flights was gradually reduced to 15 minutes.

A large number of photographs and video clips were taken during the daylight hours for the reporting period. As the average number of flights per day, according to the weather conditions and the frequency of charging the batteries, was between 17 and 20. From the video material, which was collected only with the main RGB camera of the drone, the different activities and behavioral manifestations can be clearly seen and distinguished. Photographic material, on the other hand, provides better and more reliable information on the division of animals into groups and habitats. Here, data is collected from all three cameras. It was found that RE (red edge) multispectral camera did not bring any useful information to the research. On the other hand, the RGN camera very well complements the data from the drone's main camera in the midday and early afternoon hours, when sunlight reflections are strongest. In proof of this statement, Figure 1 presents images from the three cameras in the time range from 13:30h to 14:00h and from a height of 10 meters. Fig. 2 shows a photograph of the animals' habitat from a height of 50 meters. The animals are divided physically into 4 main groups - fattening, boars, mothers and young. Animals raised for fattening, with an average age of about a year and a half, have the largest habitat area. The area of the fattening animal habitat is estimated at approximately 603 square meters. As the total area of the animals is determined to be about 1120 square meters from Fig. 2.



a b c

Fig. 1. Photos of the preferred place to rest in the heat (a mud area) from 3 visual tools: a – RGB, b – RGN, c – RE.

Fig. 2. Photo of the distribution and limits of the habitat for Mangalitsa pigs, June 2023.

An attempt has been made to determine the piglets' straight body length and an increase of approximately 10-15 cm was found for a month time period. The data is calculated based on the photos taken. Some of the pictures used are presented in figure 3 and 4.

Fig. 3. Photo of the group of small pigs, taken from a height of 10m, at the beginning of August 2023.

Fig. 4. Photo of the group of small pigs, taken from a height of 10m, at the beginning of September 2023.

Conclusions

Remote sense monitoring with an unmanned aerial vehicle (UAVs) is a valuable tool in the field surveillance and description work of domestic animals. It gives good information about behavior, habitat, preferred places of rest and eliminates human-animal conflict. The photographic and video material enable accurate filling of ethological forms, allowing subsequent analysis of the behavior of the observed group of animals. The best and preferred tool in this research is the standard RGB drone camera. While multispectral cameras have not proven to be as effective under these conditions, they are a valuable tool in studying plant life.

This method can easily be applied to wild animals as well. A necessary condition is to specify the height of the flight, with the aim of minimal reaction of anxiety or fear on the observed animal species to the presence of the drone.

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References

Allen, R., Irmak, A., Trezza, R., Hendrickx, J.M.H., Bastiaanssen, W., & Kjaersgaard, J. (2011). Satellite-based ET estimation in agriculture using SEBAL and METRIC. *Hydrol. Process.*, 25(26), 4011–4027. doi: 10.1002/hyp.8408

Anderson, K., & Gaston, K.J. (2013). Lightweight unmanned aerial vehicles will revolutionize spatial ecology. *Frontiers in Ecology and the Environment*, 11, 138-146. doi: 10.1890/120150

Anderson, M.C., Allen, R.G., Morse, A., & Kustas, W.P. (2012). Use of Landsat thermal imagery in monitoring evapotranspiration and managing water resources. *Remote Sens. Environment*, 122, 50–65. doi: 10.1016/j.rse.2011.08.025

Bennitt, E., Bartlam-Brooks, H.L.A., Hubel, T.Y., & Wilson, A.M. (2019). Terrestrial mammalian wildlife responses to unmanned aerial systems approaches. *Scientific Reports*, 9, 2142. doi: 10.1038/s41598-019-38610-x

Chabot, D., & Bird, D.M. (2015). Wildlife research and management methods in the 21st century: Where dounmanned aircraft fit in? *Journal of Unmanned Vehicle Systems*, 1, 137–155. doi: 10.1139/juvs-2015-0021

Christie, K.S., Gilbert, S.L., Brown, C.L., Hatfield, M., & Hanson, L. (2016). Unmanned aircraft systems inwildlife research: Current and future applications of a transformative technology. *Frontiers in Ecology and the Environment*, 14, 241–251. doi: 10.1002/fee.1281

Di Felice, F., Mazzini, A., Di Stefano, G., & Romeo, G., (2018). Drone high resolution infrared imaging of the Lusi mud eruption. *Marine and Petroleum Geology*, 90, 38-51. doi: 10.1016/j.marpetgeo.2017.10.025

DJI (2018) Retrieved from https://www.dji.com/

Duffy, J.P., Cunliffe, A.M., DeBell, L., Sandbrook, C., Wich, S.A., Shutler, J.D., Myers-Smith, I.H., Varela, M.R., & Anderson, K. (2018). Location, location, location: considerations when using lightweight drones in challenging environments. *Remote Sens. Ecol. Conserv.*, 4(1), 7–19. doi: 10.1002/rse2.58

Fettermann, T., Fiori, L., Bader, M., Doshi, A., Breen, D., Stockin, K.A., & Bollard, B. (2019). Behaviour reactions of bottlenose dolphins (*Tursiops truncatus*) to multirotor unmanned aerial vehicles (UAVs). *Scientific Reports*, 9, 8558. doi: 10.1038/s41598-019-44976-9

Gonyou, H.W. (2001). The Social Behaviour of Pigs. In Keeling, L.J., & Gonyou, H.W. (eds.). *Social behaviour in farm animals*. CABI Publishing. 147–176. doi: 10.1079/9780851993973.0000

Headland, T., Ostendorf, B., & Taggart, D. (2021). The behavioral responses of a nocturnal burrowing marsupial (*Lasiorhinus latifrons*) to drone flight. *Ecology and Evolution*, 11, 12173–12181. doi: 10.1002/ece3.7981

Heffner, R.S., & Heffner H.E. (1990). Hearing in domestic pig (*Sus scrofa*) and goat (*Capra hircus*). *Hear. Res.*, 48(3), 231–240. doi: 10.1016/0378-5955(90)90063-U

Hodgson, A., Kelly, N., & Peel, D. (2013). Unmanned Aerial Vehicles (UAVs) for surveying marine fauna: a Dugong case study. *PLoS ONE*, 8(11), e79556. doi: 10.1371/journal.pone.0079556

Hvala, A., Rogers, R.M., Alazab, M., & Campbell, H.A. (2023). Supplementing aerial drone surveys with biotelemetry data validates wildlife detection probabilities. *Front. Conserv. Sci.*, 4, 1203736. doi: 10.3389/fcosc.2023.1203736

Kogan, F.N.F. (2001). Operational space technology for global vegetation assessment. *Bull. Am. Meteorol. Soc.*, 82, 1949–1964. doi: 10.1175/1520-0477(2001)082<1949:OSTFGV>2.3.CO;2

Koh, L.P., & Wich, S.A. (2012). Dawn of drone ecology: Low-cost autonomous aerial vehicles for conservation. *Tropical Conservation Science,* 5, 121–132. doi: 10.1177/194008291200500202

Linchant, J., Lisein, J., Semeki, J., Lejeune, P., & Vermeulen, C. (2015). Areunmanned aircraft systems (UASs) the future of wildlife monitor-ing? A review of accomplishments and challenges. *Mammal Review*, 45, 239–252. doi: 10.1111/mam.12046

Mapir Survey 3W. Retrieved from https://www.mapir.camera/en-gb/ https://www.mapir.camera/en-gb/

McEvoy, J.F., Hall, G.P., & McDonald, P.G. (2016). Evaluation of unmanned aerial vehicle shape, flight path and camera type for waterfowl surveys: Disturbance effects and species recognition. *PeerJ*, 4, e1831. doi: 10.7717/peerj.1831

Mulero-Pázmány, M., Jenni-Eiermann, S., Strebel, N., Sattler, T., Negro, J.J., & Tablado, Z. (2017). Unmanned aircraft systems as a new source of disturbance for wildlife: A systematic review. *PLoS ONE*, 12, e0178448. doi: 10.1371/journal.pone.0178448

National Geospatial Advisory Committee (NGAC). (2012). *The Value Proposition for Ten Landsat Applications*. NGAC, Washington, DC, USA, 1–6.

Olczak, K., Penar, W., Nowicki, J., Magiera, A., & Klocek, C. (2023). The Role of Sound in Livestock Farming—Selected Aspects. *Animals,* 13(14), 2307. doi: 10.3390/ani13142307

Ramos, E.A., Maloney, B., Magnasco, M.O., & Reiss, D. (2018). Bottlenose dolphins and Antillean manatees respond to small multirotor unmanned aerial systems. *Frontiers in Marine Science*, 5, 316. doi: 10.3389/fmars.2018.00316

Rümmler, M.-C., Esefeld, J., Hallabrin, M.T., Pfeifer, C., & Mustafa, O. (2021). Emperor penguin reactions to UAVs: First observations and comparisons with effects of human approach. *Remote Sensing Applications: Society and Environment*, 23, 100545. doi: 10.1016/j.rsase.2021.100545

Schad, L., & Fischer, J. (2022). Opportunities and risks in the use of drones for studying animal behaviour. *Methods in Ecology and Evolution,* 14(8), 1864-1872. doi: 10.1111/2041-210X.13922

Schroeder, N.M., Panebianco, A., Gonzalez Musso, R., & Carmanchahi, P. (2020). An experimental approach to evaluate the potential of drones in terrestrial mammal research: A gregarious ungulate as a study model. *Royal Society Open Science,* 7, 191482. doi: 10.1098/rsos.191482

Talling, J.C., Waran, N.K., Wathes, C.M., & Lines, J.A. (1996). Behavioural and physiological responses of pigs to sound. *Appl. Anim. Behav. Sci.*, 48(3-4), 187–201. doi: 10.1016/0168-1591(96)01029-5

Vermeulen, C., Lejeune, P., Lisein, J., Sawadogo, P. & Bouche, P. (2013). Unmanned aerial survey of elephants. *PLoS ONE*, 8, e54700. doi: 10.1371/journal.pone.0054700

Walker, W.R., (2011). *Lessons for the Last Half Century of Irrigation Engineering Research—Where to Now?* IV Congreso Nacional y III Congreso Iberoamericano de Riego y Drenaje; La Molina National Agrarian University: Lima, Peru.

Weimerskirch, H., Prudor, A., & Schull, Q. (2018). Flights of drones over sub-Antarctic seabirds show species- and status-specific behavioural and physiological responses. *Polar Biology*, 41, 259–266. doi: 10.1007/s00300-017-2187-z

Yordanov, E.S., & Mollov, I.A., (2022). Comparing Two Models of UAVs (drones) as a Monitoring Tool for Freshwater Turtles. *Ecologia Balkanica*, SE 5, 33-42.

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