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Technical Note

A Manual for Monitoring Wild Boars (*Sus scrofa*) Using Thermal Infrared Cameras Mounted on an Unmanned Aerial Vehicle (UAV)

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Abstract: This study proposes monitoring methods of wild boars in plains or mountain forest areas using unmanned aerial vehicles (UAVs) equipped with infrared cameras. It is recommended to monitor in winter when the canopy layer is thin and the temperature difference between the ambient temperature and the body temperature of the wild boar is distinct, so that the infrared camera can better detect the wild boars. In flat land, the plane movement of the UAV can be easily monitored using the line transect, the point count survey, the plot sampling method, and the belted transect. In the mountain forest, there are variations in elevation due to slopes. Therefore, we introduced the WAYPOINT function to reflect the difference in altitude. After the investigator designates the waypoint, various information can be modified according to the terrain, and the WAYPOINT can be transmitted to other UAVs, so the utilization is high. In this method, once a route is created using the WAYPOINT, there is no need for additional operation after the start of the flight, and it helps to re-monitor the site by using the WAYPOINT record repeatedly. Therefore, this technical note provides a more repeatedly sustainable and scalable monitoring method than the conventional UAV method.

Keywords: wild boar monitoring; wildlife management; UAVs; thermal infrared camera

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1. Introduction

As urbanization progresses and human living spaces expand, the buffers between humans and wild animal habitats decrease and overlap [1], resulting in conflicting interests between the two groups [2]. This urbanization will continue and ultimately will intensify the conflict between humans and wildlife [3]. For example, diseases such as African swine fever are spreading to wild animals and livestock, causing enormous social and economic damages, and, similarly, zoonosis has become a serious social problem [4–6]. In addition, road kills due to habitat fragmentation not only threaten the survival of wild animals, but can also cause severe injuries to drivers [7–11]. Raccoons, deer, and wild boars also cause damage to crops in agricultural areas [12–14]. In particular, wild boars are involved in most of the conflicts, and the ever-increasing economic, social, and ecological damages caused by wild boars cannot be ignored anymore [2,15]. However, active studies on management measures to reduce the conflict between wild boars and humans have not yet been conducted.

Identifying the population of each species and analyzing any trend through monitoring is an essential part of wildlife management [16,17]. The traditional mammalian population survey methods [18,19], including total counts, indirect counts [20], capture–recapture [21], motion-sensor cameras [22,23], and trace surveys, are not suitable for the wild boar population. This can be attributed to the characteristics of wild boars, such as their expansive habitat range and strong territoriality, the difficulty in capturing large

mammals, and the non-objectivity of trace data. Therefore, developing a more efficient monitoring technique to obtain more objective data is required [24].

Unmanned aerial vehicles (UAVs), without human access and survey, can search around a large area in a short time [25]. Therefore, they offer a more effective and lower-cost approach for long-term monitoring [26]. Capitalizing on their benefits, a large number of monitoring studies for mammalian species have been conducted [27]. Recent studies using UAVs demonstrated the effectiveness of addressing the distribution and density of chimpanzees (*Pan troglodytes*) and orangutans (*Pongo abelii*) in rainforests [28,29]. In addition, using UAVs to monitor goats (*Capra aegagrus hircus*) [26] and roe deer (*Capreolus capreolus*) [30] enabled surveyors to avoid unnecessary crop damages. UAVs were also introduced to monitor marine animals, such as southern elephant seals [31] and penguins [32]. In this regard, specific protocols to monitor marine animals using UAVs have been developed [33].

Despite the high utilization of UAVs, implementing them for monitoring wild boars in mountain forests is difficult. Most of the existing protocols apply to survey areas with little altitudinal variation. If there is any variation in altitude, the flying altitude of the UAV is raised to the highest level. In this case, it may be challenging to identify the target object, resulting in a reduced accuracy. In addition, limited visibility due to altitudinal variation increases the risk of UAV collisions. However, there is no manual to supplement this. Furthermore, if a surveyor uses an infrared camera in a mountain forested area, it is difficult to detect wild boars because the thermal imaging camera is obscured by leaves and branches. Particularly, in summer, there is little difference in temperature between the wild boar and the surrounding environment, making it difficult to identify the animal. Seasonal surveys or nightly monitoring of wild boars often require the use of these thermal imaging cameras, but few studies have supplemented these conditions in mountain forests. Usually, identifying a wild boar is relatively easy from air by silhouette because it is one of the few large mammals present and has a silhouette that is distinct from other species. Therefore, the nocturnal wild boar might be suitable as a target species because it is more likely to be detected at night. Bushaw [34] described compensation for the limitation and problems of existing mammal monitoring methods using UAV and a thermal imaging camera to investigate mesocarnivores and breeding waterfowl. In the current study, we aimed to verify the optimal survey season and to present methods for monitoring wild boars using UAV equipped with a thermal imaging camera on flat land and in mountain forests with altitudinal variation.

2. Equipment

In this study, DJI Matrice 200 V2 (4.7 kg weight, 886 mm wingspan; Shenzhen, China) was used as the monitoring UAV. It was powered by a 22.8 V Lipo 65 battery, allowing for approximately 35 min of flight time. This UAV model had a collision detection system equipped with forward, downward, and top obstacle detection sensors. It also had an anti-collision beacon system that allows surveyors to know the location of the UAV in a dark environment, making it useful for nighttime recording with limited visibility. The availability of options for attaching an additional thermal imaging camera to the UAV also led us to select this model. For the infrared cameras, DJI Zenmuse XT2 (9 hz; 640 $\times$ 12 resolution; 13 mm lens) was used to detect the moving wild animals accurately. The forward-looking infrared (FLIR) cameras and 4 K visual camera enabled the surveyors to compare the actual distance and visibility while moving or creating a route for monitoring, and to confirm the identification of the wild boars after shooting. Digital zoom of up to 8 times can detect and identify the targets even at high altitudes. In order to monitor the wild boars, the camera was set to high resolution and medium angle of view. The DJI Pilot application compatible with the UAV was used in the study, and the ISOTHERM, PALLET, and WAYPOINT functions were used.

3. Different Methodologies: Their Applications, Scopes and Limitations

3.1. Monitoring Wild Boars on the Flat Ground

The UAV operation is not complicated in monitoring wild boars with UAV on flat ground where there is no change in altitude. Since there is no difference in altitude, there is little risk of collision, so there is no need to move the UAV in consideration of the altitude, and monitoring is possible by directly controlling the UAV. However, monitoring at night is recommended to detect mainly nocturnal wild boars, but visibility is not secured at night, increasing the risk of collision. Therefore, it is recommended to use the method of preparing the flight route in advance using the WAYPOINT function. In WAYPOINT, all information (altitude, camera angle, speed, etc.) of the point is stored and can be modified according to the situation later. This makes it possible to automatically fly and monitor only the saved route at night, when wild boars are likely to be detected after making a route during the day when visibility is secured. In addition, by storing WAYPOINTs, the same area can be repeatedly surveyed using a compatible UAV. The following is an introduction to monitoring methods by applying various ecological methods on flat land.

3.1.1. Line Transect on the Flat Ground

This approach was based on the line transect method that is mainly used for birds' survey. Following the basic rationale of the line transect method, monitoring started from the point to be investigated and moved up to a set distance. At the starting point, the thermal imaging camera was rotated 90 degrees to face the ground and then monitored while moving at a constant speed (Figure 1). The reason for adjusting the camera angle to the ground was to calculate the monitoring area, along with consideration of the altitude. The area that is monitored can be calculated by the flight height and field of view (FOV).

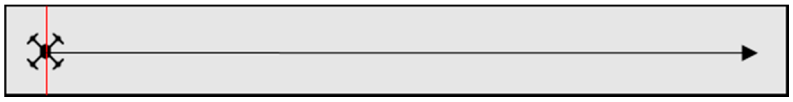


Figure 1. A monitoring route using the line transect method. The gray area is the monitoring area.

Since this technique was carried out on flat ground with little change in elevation and secured visibility, both manual flight and manual monitoring were applicable. In addition, saving the locations from the starting and ending points of monitoring through the mission flight function created a monitoring route for repeat monitoring with a constant speed. If UAVs are flying low in altitude and the flight speed is slow, wild boars can easily be detected. The line transect method is straightforward, and the UAV flight operation is simple. Therefore, this method is relatively easier to conduct than other monitoring methods, since surveyors only have to control the drone linearly. Moreover, information on GPS coordinates for monitoring routes and flying altitudes can be stored and extracted, which easily allows for further calculation of the monitoring area. However, since this method can only move in a straight line, only a relatively small area of the space can be sampled with one trial. Thus, a large number of samples are required when large area is monitored.

3.1.2. Point Count Survey on the Flat Ground

This monitoring technique was inspired by the point count survey method and the circle plot sampling method of vegetation among the birds' survey methods. This monitoring technique involves hovering on a spot and rotating the UAV 360 degrees repeatedly while adjusting the camera angles [34] (Figure 2).

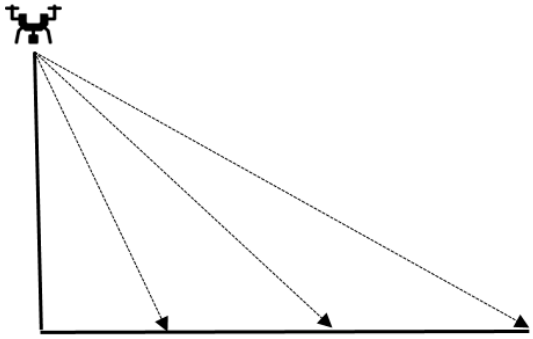


Figure 2. Schematic diagram of the point count survey method modified from Bushaw [34].

First, the UAV was moved by manual flight to the point of investigation, and then the infrared camera was rotated 90 degrees to face the ground. Second, the camera gimbal angle was adjusted so that half of the area was visible on the screen, and the UAV itself was rotated 360 degrees. This step allows for monitoring of the circular area. Third, after the rotation, the camera gimbal angle was tilted horizontally so that approximately 10% of the broadened observational area overlapped with the previous one, and then the UAV was rotated slowly by 360 degrees again while monitoring. Steps 1 to 3 were repeated more than 2 times. Figure 3 shows the monitoring area. In this case, the camera gimbal angle was adjusted within 45 degrees. As the camera gimbal's angle became lower, the accuracy decreased because it detected wild animals in a distant area. The detection of ground-dwelling wild boars failed because the camera was pointed toward the upper layers of the forest.



Figure 3. Schematic diagram of the monitoring area that can be photographed through the point count survey method. The concentric gray circles represent image acquisition areas, and the dark gray part is the overlapping area.

Bushaw [34] suggested that the detection area was limited to a radius of 125 m at an altitude of 75 m, which adjusts the camera angle between 0 to 45 degrees. However, the angle to be adjusted should differ by flight conditions, including the flying altitude and forest conditions. The 40 to 60 m range of flying altitude is commonly recommended on flat ground. This is because wild animals are affected by UAVs; they are frightened and run away when the altitude is below 45 m [34]. In present study, wild boars reacted to the UAV and moved away during monitoring at 40 m flying altitude. The lower the UAV's altitude or the larger the magnification of the infrared camera, the smaller the area that would be displayed on the screen. Therefore, angle adjustment should be carefully conducted. Depending on the survey area, manual UAV control can also be used in the survey.

This technique involves minimal UAV movement and flight by rotating and monitoring at one point. It reduces the risk of collision while moving to the survey spot so that even non-UAV experts can perform the monitoring easily. In addition, merely by changing the camera angle, surveyors can monitor a large area in a short time. Unlike other techniques, it can be observed obliquely due to the camera angle effect, so the detection rate is higher than when moving vertically. When the camera monitored the ground at 90 degrees (Figure 4), the area covered by the canopy layer could not be detected. However, observation at an oblique angle captured images of the same canopy-covered area (Figure 5). Finally, storing the locations of the monitoring points allowed for repeated monitoring surveys, thereby tracking temporal changes in wild boar populations.

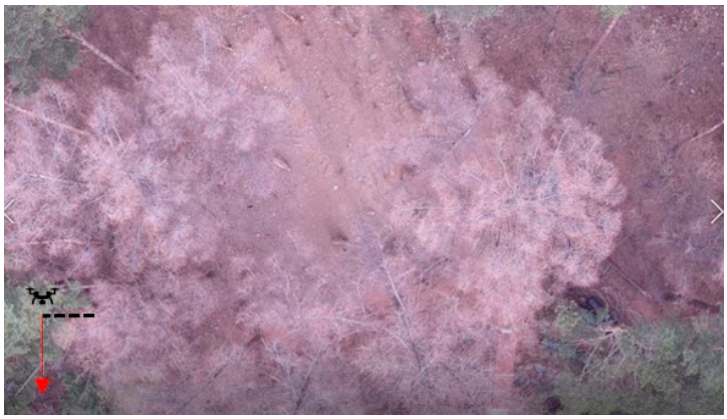


Figure 4. The monitoring screens of a portion of the whole area on November 2020 using 90 degrees angle.



Figure 5. The monitoring screens of a portion of whole area on November 2020 using approximately 79 degrees angle.

The only disadvantage of this technique is that it requires manual manipulation of the UAV and camera gimbal for adjusting the angle and the speed at which the UAV rotates. It is recommended to proceed at a low speed for better detection of the wild boar.

3.1.3. Plot Sampling Method on the Flat Ground

The plot sampling method is mainly used for plant population surveys. On flat land with a secure view, the plot sampling method can be conducted in a simple way using the DJI application, which creates a path at the desired location automatically. The mission flight-mapping function of the DJI Pilot application creates a rectangular route (Figure 6) by simply clicking the point on the displayed map. Once a route is created, the distance between the routes, total area, and altitude can be modified depending on the survey area.

Then, according to the modified configuration, monitoring is performed through automatic flight mode at a given speed. The automatic route creation function is a convenient monitoring strategy for plot sampling on flat grounds. With the function, the surveyors do not need to control the UAV manually to create a route; instead, routes can be monitored at regular intervals and speeds automatically. Therefore, the manipulating time is shortened and a large number of samples can be obtained. However, such automatic route creation can sometimes be a disadvantage too, compared to manual creation, in identifying the topographical characteristics of the survey area. This is because it is impossible to check the risk of collision due to changes in altitude and obstacles in the path. Furthermore, one should be cautious in applying this method to non-flat ground.



Figure 6. Schematic diagram of a plot sampling method using UAV.

3.1.4. Belt Transect Method on the Flat Ground

The belt transect is a method that collects data from the sampling area, which has a certain width along the baseline. An extended detection area by UAV can increase the efficiency of the belt transect method for wild boar monitoring. There are two approaches of the belt transect: (1) using the points and lines (Figure 7a) introduced earlier, and (2) using the square sphere method and using the line in parallel (Figure 7b). A combination of the point count survey and the line transect refers to first performing the point count survey at the point to be investigated, followed by moving along a straight line and repeating the point count survey at the next point. A combination of the plot sampling method and the line transect approach is suitable when a route is created according to the change in altitude. A series of surveys on a route that is circle or square-shaped (i.e., belt transect method) are conducted repeatedly along a straight line for a certain distance. It is effective for monitoring a large area, but it consumes a large amount of the battery and time because the surveyor has to create a route for each point.

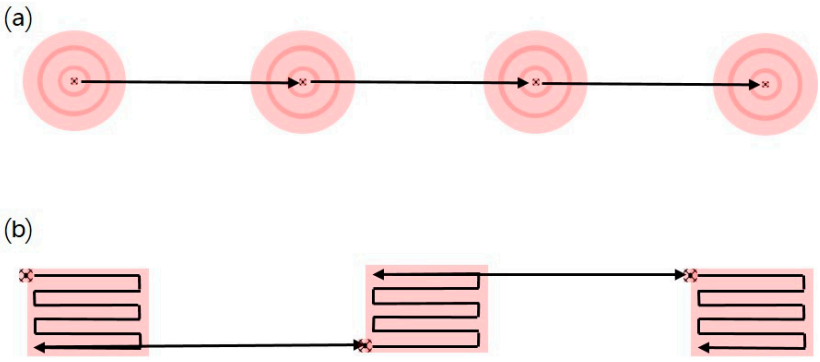


Figure 7. Examples of belt transect method using UAVs: (**a**) combining the point count survey and the line transect, (**b**) combining the plot sampling method and the line transect.

3.2. Monitoring Wild Boars in Mountain Forests

All of the monitoring approaches described in the previous section are suitable for use in terrains with a little elevation change or in monotonous terrains. However, in mountain

forests where most wild boars live, there are many constraints in using the simple methods for flat land due to significant fluctuations in elevation. When monitoring in a mountain forest with large topographical variation, manual adjustments consume a large amount of time and battery, and increase the risk of a crash. In addition, the monitoring methods for a flat land do not apply to the mountain forest, because the acquired images do not account for the altitudinal variations and the surveyor cannot calculate the survey areas accurately. Therefore, operating the UAV while modifying the flying altitude according to change in elevation is essential to obtain accurate data. For this, it would be better to create a route in advance and then monitor it through automatic flight rather than manual operation. Across the following sections, additional points that surveyors should consider for monitoring mountain forested areas will be introduced with regard to monitoring techniques.

3.2.1. Line Transect in Mountain Forests

The major difference between the line transect methods of mountain forests and flat land is that the flying altitude of the UAV changes by topographical variation for the former. For an ascending slope in mountain forest, the route of a UAV can be constructed by the following steps. First, save the starting point. Second, move the UAV along a straight line, and, if it encounters a slope with increasing elevation, stop where the hill starts and save the waypoint. Third, increase the altitude vertically to the level of the corresponding elevational change ends, then move the UAV to the straight line and save the final waypoint. Once the route is constructed, save it, set a constant speed, and monitor using automatic flight mode. At this time, the UAV will fly in a diagonal direction along the slope. Figure 8a shows both manual and flight routes of an ascending slope. If there are multiple changes in a slope, repeat the above procedure while saving each point where the slope changes. In the case of a descending slope (Figure 8b), the route can be constructed in a reverse manner. Save the first waypoint of the route and the point where the elevation starts to decrease. Move the UAV straight and horizontally where the elevational change ends. Lower the UAV vertically to save the last waypoint. The UAV will fly horizontally until the downhill starts and will move down the slope diagonally toward the lower waypoint.

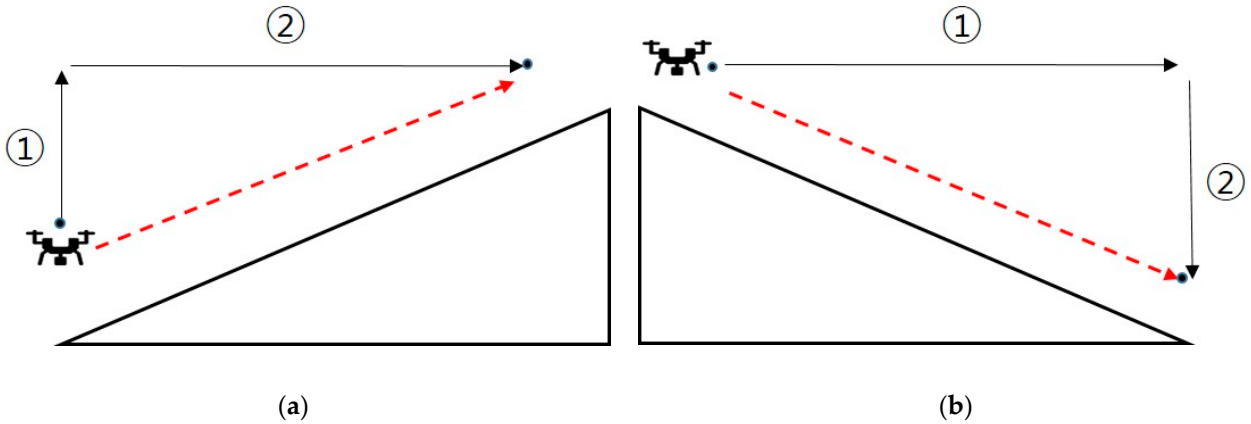


Figure 8. Example of UAV operation in terrain with a change in elevation. (**a**) When the elevation increases, raise the UAV vertically at the point where the change starts and then proceed again. (**b**) When the elevation decreases, descend vertically from the point where the elevation is lowered and then designate a waypoint. The black dots are where the waypoints will be saved. Dotted lines are the flying routes between the waypoints when the automatic flight is performed.

Although this route construction by topographical change can make large area monitoring in mountain forests more efficient and accurate, there are some disadvantages. Since the flight resumes after stopping for a while at each waypoint, there may be shaking of the aircraft if the speed is high. In addition, in an area with multiple topographical changes, the accurate area calculation may become complicated.

3.2.2. Point Count Survey in Mountain Forests

Since this technique controls the UAV at one place during monitoring, the monitoring method on flat lands can apply to mountain forests without any additional function. When monitoring is finished at one point, the UAV moves to the next point, and the route construction using WAYPOINT introduced for the line transect in mountain forests in Section 3.2.1 can be used to maintain a consistency across the survey campaigns.

In a point count survey using UAV, finding an optimal combination of altitude and magnification is critical for successful detection and identification of wild boars. At an altitude of 40 m or less, monitoring can be carried out without magnification. However, in mountain forests, it is difficult to manipulate UAVs with an altitude lower than 40 m, and it is not recommended because it affects the animals. Altitudes ranging from 40 to 70 m (Figure 9) are effective in conduct monitoring at a magnification of 2 or 4 times.

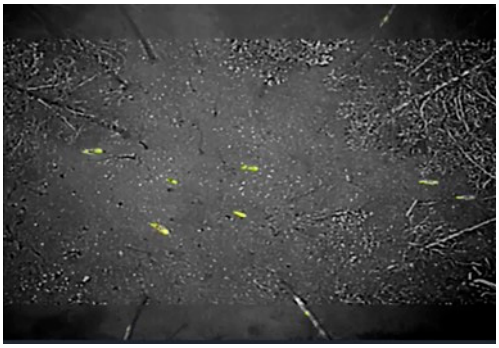


Figure 9. Wild boar silhouette taken at 1x magnification from an altitude of 40 m.

In our experience, when the monitoring altitude was 60 m, the detection performance of the infrared camera was the best, and species identification was easy. Monitoring at an altitude of 70 m or higher required 4- or 8-times magnification to distinguish the shape of the wild boar. This technique is the most effective method, with a low risk of collision, because monitoring requires the least amount of flight of UAVs in the mountain forest without altitudinal changes. Even at higher altitudes, surveyors can capture images clear enough to distinguish the silhouette of the wild boar by increasing the magnification or changing the camera angle. Figure 10 shows the comparison of a wild boar silhouette.

3.2.3. Plot Sampling Method in Mountain Forests

Although a route was automatically set using the mapping function on flat ground, any elevation changes in mountain forests are not reflected by the function, resulting in an increased collision risk. Therefore, it is necessary to create a route and monitor it in a way that stores waypoints at each point where there is a change in altitude while flying manually. In the first step of creating a route, move as much as the horizontal length of the area to be monitored (it is okay to start vertically). If there is an elevation change, proceed in the same way as the line transect method introduced in Section 3.2.1. Second, when it reaches the endpoint of the horizontal length, save the waypoint, move in the vertical direction, and save the point. Then, fly in the horizontal direction, accounting for the elevation change, and save the route. After setting the appropriate flying conditions according to the monitoring area and the remaining battery level of the UAV, repeat the above two steps to complete a route and then proceed with monitoring. If a surveyor needs to stop due to a battery problem in the middle of constructing a route or monitoring, the surveyor can start flying again from the last point where they stopped. The recommended monitoring speed in this technical note is 2 m/s according to battery performance, object detection accuracy, and monitoring area. If the altitude is high, the speed can be slightly faster. However, when monitoring with digital zoom, proceeding at 1.5 m/s or less is the most effective for detecting wild boars.

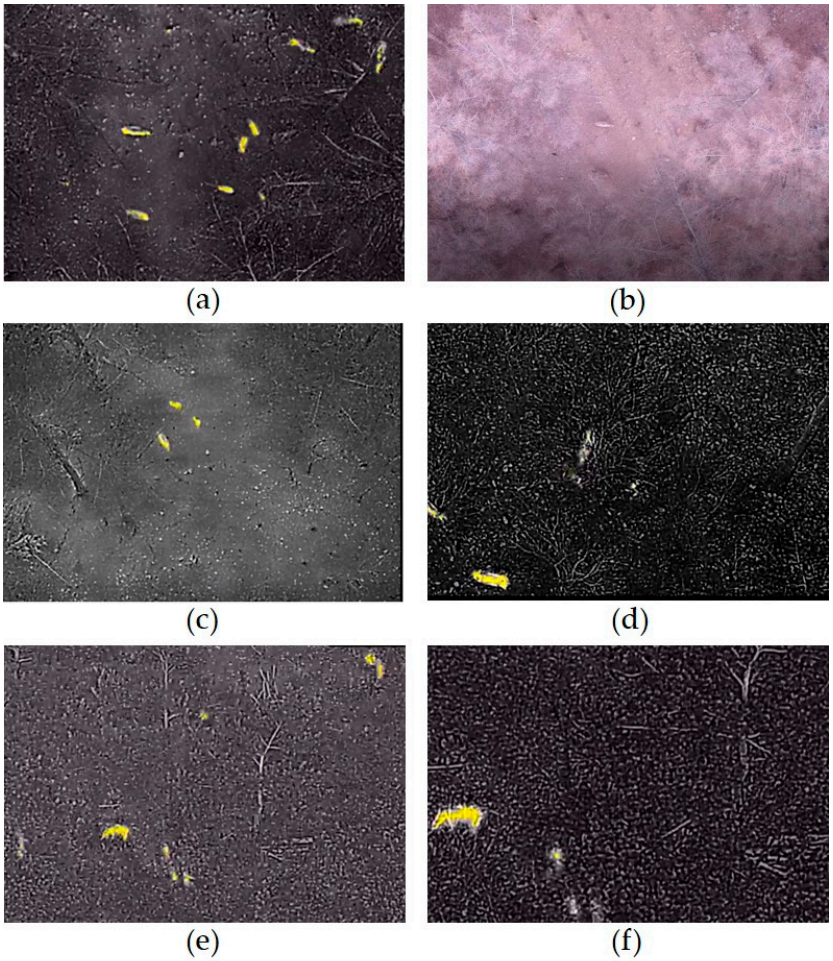


Figure 10. Acquired images during wild boar monitoring from thermal imaging camera and a normal RGB camera using the point count survey method. Note that, when using the point count survey method, the wild boar silhouette is more clearly visible than other methods due to the camera angle adjustment. (**a**) Wild boar silhouette shot with a thermal imaging camera at 50 m altitude with 2× magnification. (**b**) Wild boar shot simultaneously with a regular RGB camera at 50 m altitude with 2× magnification. Wild boar silhouette shots with a thermal imaging camera (**c**) at 60 m altitude with 2× magnification, (**d**) at 60 m altitude with 4× magnification, (**e**) at 70 m altitude with 4× magnification, and (**f**) at 70 m altitude with 8× magnification, respectively.

This approach is suitable for mountain forests because it is vertically movable and adaptable to elevation changes. In DJI Pilot application, surveyor can edit each saved waypoint information, such as altitude, camera angle, and flight speed, without additional flight. In addition, the route can be permanently stored for repeated monitoring. Furthermore, a route can be expandable with other saved routes, resulting in monitoring a wide range of areas. The compatible data format (i.e., kml file) of the route is highly useful, since it can be used interchangeably across the UAV models. However, if the changes in flying altitude are severe, it takes excessive time for beginners to create a route.

3.2.4. Belt Transect Method in Mountain Forests

This method can be used in the same way as the belt transect method on flat ground. If there is any need to modify the flying altitude when moving from one point to another, surveyors can set the route in the same manner as the line transect method, with an altitudinal variation.

3.3. Using Reconnaissance UAVs

When monitoring using UAV in mountain forests, there is always a high risk of collision due to altitudinal fluctuations and many other factors (i.e., electric pole, trees, and bird strike). Several batteries are required to create a monitoring route, but the battery of a UAV for monitoring is expensive and can cause costly equipment loss in the event of a crash. UAV crashes are time-consuming and expensive to repair, which can hamper timely monitoring studies. Therefore, we introduced a reconnaissance drone as a low-cost device. The introduction of the reconnaissance UAV was inspired by the fact that a route can be saved and retrieved by other UAVs. After checking monitoring area and creating the route using the reconnaissance UAV, the file with geographical information of the route can be transferred to the monitoring UAV. In the present study, the DJI Mavic 2 zoom (0.9 kg weight, 322 mm wingspan; Shenzhen, China) was used as a reconnaissance UAV because it is compatible with the monitoring UAV. For a flight time of approximately 31 min, the reconnaissance UAV outperformed other models with similar specifications, so it was efficient for developing routes.

A reconnaissance UAV has the advantage of low-cost equipment and batteries. Before starting with the monitoring UAV, the reconnaissance UAV can check the topography of the survey area while making the route first, so any potential risk of collision in the monitoring route can be detected in advance, ensuring stability. Since the reconnaissance UAV is used only to establish a route, it can be used at any time regardless of the change in seasons. In addition, the safe route confirmed by a reconnaissance UAV dramatically improves the efficiency and safety during nighttime when it is difficult to fly due to poor visibility. This strategy can also be useful for monitoring other nocturnal animal species.

3.4. Optimal Monitoring Time

When monitoring with a UAV equipped with an infrared camera, the ecological characteristics of the target species and the performances of the UAV and camera need to be considered. For example, after breeding season, wild boars live in a maternal herd and breed throughout the year. However, most breeding is concentrated in February–July [35], so the population density is expected to be highest during that period. They inhabit mainly in forested areas and are mostly nocturnal, but may also be active during the day [36]. Moreover, seasonality should be considered, along with the behavioral characteristics of wild boar. In Korea, where there is a temperate climate with four distinct seasons, temperate broadleaf forests, as well as coniferous forests, have very dense and closed canopies, especially in summer. Therefore, both the temperature of the canopy and the ambient temperature increase during this time, which interferes with the view of the camera. Thus, there is insufficient temperature difference for the infrared cameras, making it difficult to detect wild boars. In contrast, in winter, both lower foliage thickness and lower ambient temperature make it easier to detect wild boars using a thermal imaging camera. In the same manner, monitoring at night might increase monitoring efficiency, since increased wild boar activity increases the detection probability and temperature difference between wild boar, and ambient temperature reaches maximum.

4. Conclusions

This study described a manual for wild boar monitoring techniques in mountain forests using a UAV equipped with an infrared camera. A monitoring method can be chosen among the line transect, the point count survey, plot sampling method, and belt transect depending on the situation. On flat ground, a proposed survey method without a particular operation method can be selected. However, in mountain forests, calculating the monitoring area is difficult due to the fluctuating elevation, and flying along different altitudes has a high risk of collision for beginners. Therefore, the point count survey method is the most effective, since it requires the least UAV flights, and the monitoring is less affected by altitudinal variation. Places with little change in altitudes are suitable for beginners to use the line transect method with less UAV manipulation. A plot sampling

method or a belt transect method can be considered for skilled surveyors, since they can monitor a larger area with altitudinal variations.

The collision of UAV is the most important factor to avoid when monitoring wild boars in mountain forests. Since UAVs for monitoring are expensive equipment, it is advisable to use reconnaissance UAVs. For reconnaissance UAVs, equipment should be selected that is compatible with the monitoring UAVs. Establishing a route using a reconnaissance UAV enables surveyors to detect the potential risk of collision in advance. In addition, relatively inexpensive batteries for reconnaissance UAVs relieve the budget burden, since monitoring route establishment involves a large battery consumption. Since a monitoring route can be established in all seasons with reconnaissance UAVs, when the efficiency of thermal imaging camera is low, a monitoring survey can be performed efficiently with a monitoring UAV along the route in winter and at night with a lower risk of collision.

The WAYPOINT function facilitates repeated monitoring. A created route containing the information of waypoints and the corresponding flight configuration can be modified as needed, and the monitoring route can be extended over the existing route. Once a route is created, it can be used repeatedly in the future to trace the habitat movement and population dynamics of wild boars through monitoring the same location every time.

However, there are many factors to consider when monitoring wild boars with UAVs. To minimize the risk of collision while monitoring, we recommended the use of reconnaissance UAVs. However, basic training on UAV flight is still required by surveyors because careful manipulation capabilities, such as the speed of rotating the UAV itself and angle adjustment, play an important role in monitoring. Mountain forests are distributed all over the world, and there are many UAV flight-restricted areas, such as military bases and control towers near the mountain forests. Therefore, a permit is required for night flights of UAVs. Therefore, consultation with local management agencies is required to monitor nocturnal wild boars.

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