drones

Communication

A New Method for Surveying the World's Smallest Class of Dragonfly in Wetlands Using Unoccupied Aerial Vehicles

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Abstract: Field surveys in wetlands are limited by the difficulty in accessing the site, hazards during surveys, and the risk of disturbing the ecosystem. Thus, the use of unoccupied aerial vehicles (UAVs) can overcome these limiting factors and can assist in monitoring small organisms, such as plants and insects, that are unique to wetlands, aiding in wetland management and conservation. This study aimed to demonstrate the effectiveness of a survey method that uses a small drone equipped with a telephoto lens to monitor dragonflies, which are unique to wetlands and have been difficult to survey quantitatively, especially in large wetlands. In this study, the main target species of dragonflies was *Nannophya pygmaea*, which is the world's smallest dragonfly (about 20 mm long). The study area was Mizorogaike wetland (Kita Ward, Kyoto City, Japan). The UAV was flown at a low speed at an altitude of 4 m to 5 m, and images were taken using 7× telephoto lens on Mavic 3 (7× optical and 4× digital). A total of 107 dragonflies of seven species were identified from the photographs taken by the drone. *N. pygmaea*, about 20 mm long, was clearly identified. Eighty-five dragonflies belonging to *N. pygmaea* were identified from the images. Thus, by using a small drone equipped with a telephoto lens, the images of *N. pygmaea* were captured, and the effects of downwash and noise were reduced. The proposed research method can be applied to large wetlands that are difficult to survey in the field, and can thus provide new and important information pertaining to wetland management and conservation. This research method is highly useful for monitoring wetlands as it is non-invasive, does not require the surveyor to enter the wetland, requires little research effort, and can be repeated.

Keywords: dragonfly; *Nannophya pygmaea* Rambur; monitoring; wetlands

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1. Introduction

Field surveys in wetlands face several challenges, such as difficulty in accessing the site, hazards during surveys, and risks of disturbing the ecosystem [1]. However, these challenges can be overcome by using unoccupied aerial vehicles (UAVs) for monitoring wetlands [2] and managing and conserving the wetland ecosystem [3]. UAVs can monitor wildlife populations and their habitats and also significantly reduce human access and survey time compared to field surveys [3]. Most of the studies on wetland wildlife that have used UAVs have focused on birds [3]. Using UAVs to monitor smaller organisms, such as wetland-specific plants and insects, can aid in the effective management and conservation of the wetland. In general, the UAVs need to fly at very low altitudes to capture images of organisms as small as a few centimeters. However, flying at such low altitudes increases the risk of UAVs coming into contact with the tall-stemmed grasses and shrubs growing in wetlands, and the downwash and noise generated by the UAV can affect the target organisms. In recent years, smaller UAVs equipped with telephoto lenses have been developed. The telephoto lenses allow UAVs to capture organisms as small as a few centimeters from a much higher altitude without affecting the target organisms.

Therefore, this study aimed to demonstrate the effectiveness of a survey method using a small drone equipped with a telephoto lens in examining dragonflies, which are unique to wetlands and have been difficult to survey quantitatively in wetlands with large areas.

2. Materials and Methods

2.1. Target Species

Our survey targeted the dragonflies inhabiting wetlands, and the *Nannophya pygmaea* Rambur was the main target species (Figure 1). *N. pygmaea* is widely distributed from East Asia to Southeast Asia and Australia [4]. It is the smallest dragonfly species in the world, measuring approximately 20 mm in length [4]. The species is mainly distributed in the Honshu, Shikoku, and Kyushu islands of Japan [5]. However, its distribution area is declining significantly due to the loss of habitat caused by vegetation succession in wetlands (in many cases, terrestrialization due to accumulation of dead plants) and loss of wetlands themselves due to development [5]. In Kyoto Prefecture, where the study site is located, *N. pygmaea* is listed as a near-threatened species, and many other prefectures in Japan have listed it as a threatened species. *N. pygmaea* was selected as the major target species for this study as the species are suitable for demonstrating the effectiveness of the survey method using a small UAV equipped with a telephoto lens. This is because, if the smallest species can be detected, it can be applied to many other species, and is useful for monitoring changes in wetlands because it is a wetland indicator species.

Figure 1. *Nannophya pygmaea*, the main target species, photographed on the ground during the survey at the Mizorogaike wetland on 9 September 2022. Male *N. pygmaea*, about 20 mm long.

2.2. Study Area

This study was conducted on the Mizorogaike wetland (Kita Ward, Kyoto City, Kyoto Prefecture), which lies close to the borders of an urban area (Figure 2). The wetland is a freshwater and a rare ecosystem that has survived from the glacial period to the present. It includes a 2 m depth pond with an area of 8 ha and contains a floating mat formed by peat (rare in the lowlands of western Japan) that covers approximately one-third of its surface ([6], Figure 3). It is difficult to survey on foot, and surveys can only be carried out by boat. In Japan, the Ozegahara marshland and the Mizorogaike wetland are well known for their abundance of *N. pygmaea* [5]. Therefore, the Mizorogaike wetland was selected as the survey site for this study.

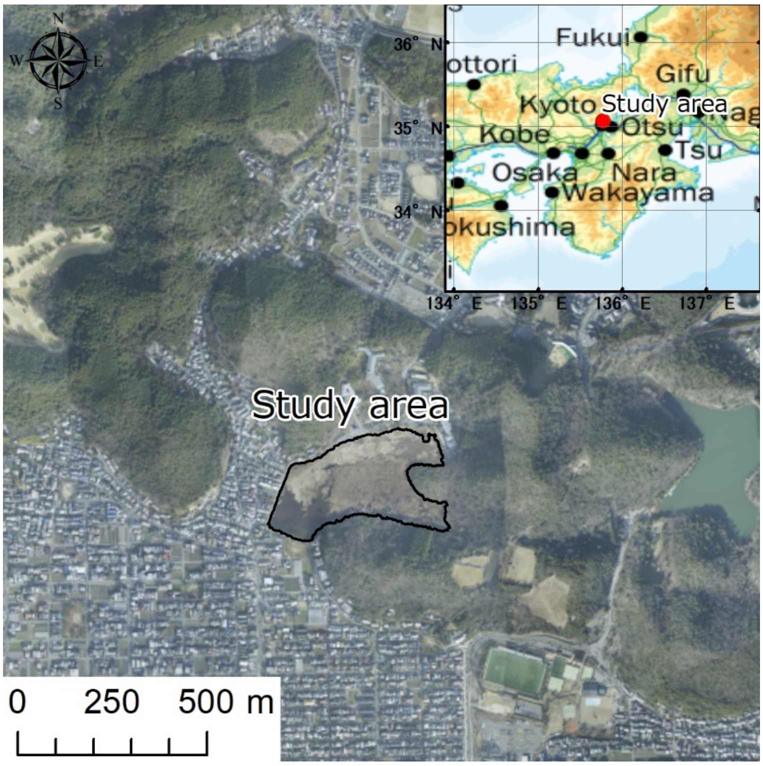

Figure 2. Survey area considered for this study.

Figure 3. Floating mat formed by peat observed on the east side of the Mizorogaike wetland, photographed on 10 October 2019. Most of the wetlands are floating mat, making them difficult to survey on foot.

2.3. Dragonfly Survey

The DJI Mavic 3 camera drone was used for conducting the survey. First, using multiple survey lines that can cover the entire wetland, the drone was flown manually at low speed and at an altitude of 4 m to 5 m over the entire survey area in the wetland. While flying over the survey area, the drone took images every few meters by using its 7× telephoto lens on the Mavic 3 (7× optical and 4× digital). The survey was repeated five times, i.e., on 28 June, 29 July, 3 August, 8 August, and 9 September 2022. Each survey took approximately 50 min. The images captured were 4000 × 3000 pixels, displayed on a full screen of 2560 × 1440 pixels. Most of the images were of legible quality, although there were some out-of-focus images when the drone was not at a complete stop, or when there were shrubs. Each image was viewed for approximately 20–30 s, and if a dragonfly was observed in the image, then its species name was recorded. To verify the accuracy of the identification of *N. pygmaea*, one additional person was added to the identification. The DJI Mavic 3 is equipped with global navigation satellite system (GNSS), which records the shooting position on the captured images. The geographic information system (GIS) was used to create point data from the XY-coordinates of the shooting position recorded in the images. Accordingly, the distribution data of dragonflies were created by combining the point data with the species name.

3. Results

A total of 3286 images were taken during the five surveys. By using these images, 122 dragonflies of seven species were identified (Table 1). However, individual identification was not possible, so if the dragonflies were migrating, the same individual may have been counted. *N. pygmaea*, about 20 mm long, was clearly identified (Figure 4). Objects smaller than 20 mm were also identified, so the image resolution was sufficient to identify *N. pygmaea*. The largest number of dragonflies identified was 100 from *N. pygmaea*, and only three of them were females. About 3.04% of the total number of photographs taken included individuals of *N. pygmaea*. Of the 100 *N. pygmaea*, 63 (63%) could be identified by both identifiers. The distribution of dragonflies in the five surveys is shown in Figure 5.

Table 1. Number of identified dragonflies.

Scientific Name	2022					Total	%
	28-Jun	29-Jul	3-Aug	8-Aug	9-Sep		
Nannophya pygmaea	2	36	14	27	21	100	3.04
Ceriagrion melanurum		4	2	3		9	0.27
Ceriagrion nipponicum				1		1	0.03
Rhyothemis fuliginosa		3	2			5	0.15
Orthetrum albistylum			2			2	0.06
Crocothemis servilia		1		1		2	0.06
Sympetrum sp.					3	3	0.09
Total	2	44	20	32	24	122	
Number of photos	327	720	730	758	751	3286	

Figure 4. Images containing confirmed spotting of *N. pygmaea* as shown at the tip of the arrow.

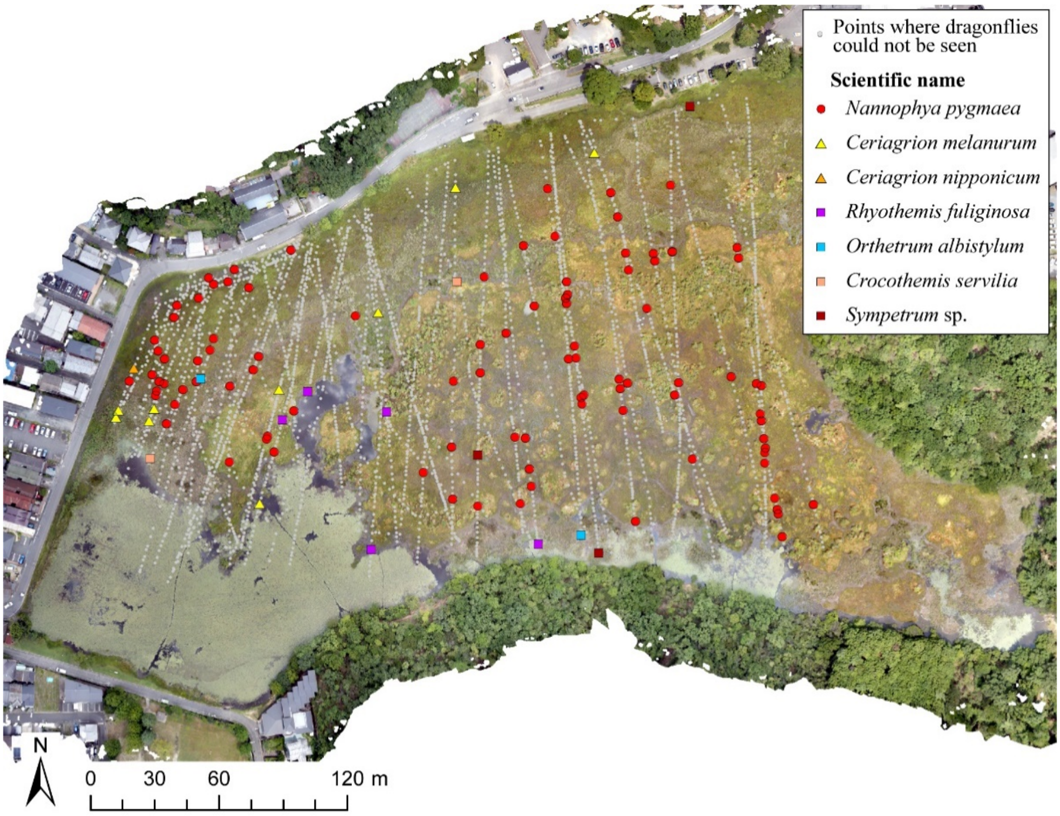

Figure 5. Distribution of dragonflies in our survey area based on the combined results of the five surveys. The background is an orthomosaic image of 26 July 2022.

4. Discussion

4.1. Usefulness of the Proposed Method for Surveying Dragonflies

A total of 100 *N. pygmaea* could be identified from the images taken during the survey. By using a small drone equipped with a telephoto lens, the effects of downwash and noise were reduced, and the main survey target was identified. However, individual identification was not possible, so if *N. pygmaea* were migrating, the same individual may have been counted. Identification rates are affected by species mobility and seasonal variation in emergence. It is inferred that *N. pygmaea* is an easy species to identify using the methods of this study because *N. pygmaea* often form territories and settle there. Of the other six species, *C. melanurum* and *R. fuliginosa*, which had relatively high identification rates, migrate at low speeds and have seasonal variation in emergence similar to those of *N. pygmaea*. In addition, since of the 100 *N. pygmaea*, 63 could be identified by both identifiers, it can be said that the experience of the person viewing the images also affects the identification rate. Three of the identified *N. pygmaea* dragonflies were females. This observation could be because the mature males are red in color and easy to spot, whereas the females were camouflaged and resembled the vegetation, making them undetectable. In addition, mature males perch on vegetation and form territories in open areas with a water surface, whereas females stay in grassy areas near the water's edge [7]. Therefore, it is possible that, although a few females were present in the photographed area, they were not visible on account of being hidden by taller plants. Most of the individuals observed near the takeoff/landing point during the survey were also males, with only one female.

The distribution of *N. pygmaea* has been studied in detail in small areas of wetlands, such as the remains of rice paddies, by traversing the area, e.g., [7–11]. *N. pygmaea* is abundant within the floating mats with a midge moss community in the central area in the Mizorogaike wetland [10]. The distribution of male *N. pygmaea* can be better understood by using the proposed methods of this study, which will provide unprecedented information for wetland management and the possibility to monitor changes in wetlands.

4.2. Future Prospects

The proposed method used in this study can determine the distribution of *N. pygmaea* and, thus, support wetland management and conservation. This research method can be applied to large areas of wetlands that cannot be sufficiently monitored using field surveys and can, therefore, present new information for wetland management and conservation. The proposed method is non-invasive. Thus, this method does not require the surveyor to enter into the wetlands and requires little effort for a survey that can also be repeated.

The DJI Mavic 3 used in this study does not support automatic navigation and was, thus, operated manually. However, more quantitative monitoring on the same flight route can be achieved by using a drone that supports automatic navigation. Since the method used is non-invasive, the use of high temporal resolution for monitoring the survey areas does not affect the wetlands. In addition, the identification and counting of dragonflies in the taken images were performed visually and influenced by the experience of the person viewing the images. This decipherment process could be automated by using artificial intelligence in the case of a higher number of samples.

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