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Research Article

Compact, Consumer off the Shelf Remotely Piloted Aircraft Systems (COTS-RPAS) in Observing Haliastur indus, the Kali, or Brahminy Kites

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The paper demonstrates how compact consumer off-the-shelf remotely piloted aircraft systems (COTS-RPAS) with digital zoom capability are an effective remote sensing platform for observing Brahminy Kites due to their non-intimidating nature, which arguably minimizes disturbance to the kites. The paper, through this remote sensing platform, was able to conduct preliminary documentation of some key courtship, play, cooperative fishing, and other behaviors of the raptors, as well as draft a distribution map of sightings within the raptors' range, utilizing the compact COTS-RPAS in tandem with Geographic Information Systems. The use of COTS-RPAS opens a new window or point of view (POV) to avian observational and behavioral studies, especially because we are now given horizontal near-orthogonal and orthogonal views of the avian species while in flight. Most documentation of birds in flight typically shows the underwing and underbody parts, but now, with the aid of COTS-RPAS, we see the upper wing and upper body while in flight. This new tool and method also democratize environmental research for both scientists and citizen scientists due to its availability (consumer off-the-shelf), as well as its relative affordability.

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Introduction

Haliastur Indus, or Brahminy kite (see Figure 1), is a raptor that is called locally as Kali or Dialombog. Other common names include Red-backed sea eagle and Singapore bald eagle. The Kali is considered to be the manifestation of the angel Garuda, the vehicle of Vishnu in Buddhism, in many parts of Asia. The Kali occurs throughout the Philippine islands. The Kali range that has been documented in this research is within my home province of La Union. The hotspot of the sightings appears to be along the Baroro River, which is one of the notable drainage basins in the province and in Northwestern Luzon Island (see Figure 2). It is presently a site for aquaculture in its near coastal river channel (NCRC). Upriver also drains some patches of steaming Luzon Rainforests characterized as tropical and subtropical moist broadleaf forests (TSMF). The Baroro NCRC features a diverse palimpsest of flora and fauna. Avian fauna includes resident, migratory, nonmigratory, endemic, and non-endemic species.

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Figure 1. Taxonomic details of Brahminy kite (Kali Photo by Author using DJI Mavic 2 Pro 2021).

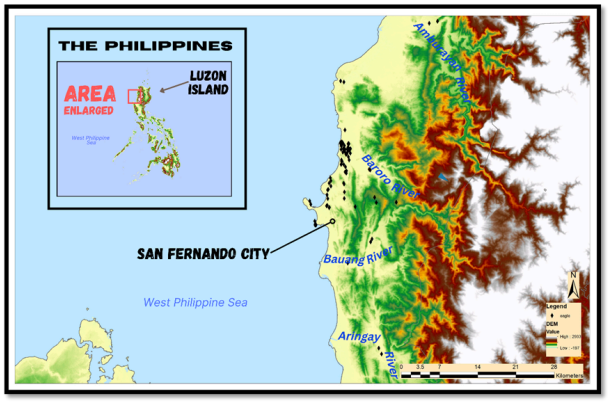

Figure 2. Research Area, Map showing sightings of Kali (WGS 1984, SRTM is a product of NASA).

The Kali is arguably the most conspicuous fauna in the Baroro River NCRC. Based on studies by Encisa-Garcia, et.al. 2021, Encisa-Garcia, et.al. 2020, Ramirez, et.al. 2019, Tolentino 2017, and Cruz, et.al 2014, the forest cover of the Baroro watershed is threatened by fragmentation due to conversion to agricultural and residential lands. Pascua, Chelo, and Enrico C. Paringit (eds.) also used light detection and ranging (LiDAR) to model the possible impact of rising floodwaters due to sedimentation in the Baroro River, which is a secondary effect of deforestation in the headwaters. While the International Union for Conservation of Nature (IUCN) has labelled the Brahminy kite as "Least Concern," locally in the Philippines, the raptor is threatened by illegal wildlife trade (DENR-BMB 2019) and deforestation.

The general objective of the paper is to demonstrate how small, compact, and lightweight consumer off-the-shelf remotely piloted aircraft systems (COTS-RPAS, compact COTS-RPAS) with zoom capability are promising remote sensing platforms in observational studies of raptors. The Brahminy kite, through the lens of COTS-RPAS, is presented here as a specific case study in La Union, Northwestern Luzon, Philippines. The state of research is preliminary at this point and is heavier on the qualitative side than the quantitative side (limitation). The section on secondary analysis suggests future directions that can integrate more mixed-method qualitative and quantitative approaches. What is important to highlight now are the new perspectives offered by compact COTS-RPAS.

Method

This observational research on wild populations of the Brahminy kite was conducted in adherence to Bird Watching Guidelines (Technical Guidelines 2017 No. 2) issued by the Department of Environment and Natural Resources Biodiversity Management Bureau (DENR-BMB). Sighting reports were also forwarded to the regional field office of the DENR. The research is also in conformity with Unmanned Aerial System laws (UAS Laws / RPAS Laws) promulgated and enforced by the Civil Aviation Authority of the Philippines (CAAP). While the author attempts to show the immense utility of using small, compact, and lightweight consumer off-the-shelf unmanned aerial systems (COTS-RPAS) in remote sensing of wildlife, including avian fauna, it should be clearly stated that anyone who intends to use COTS-RPAS *should get the prerequisite formal training and experience (flight hours)* in using COTS-RPAS *prior to attempting to document wildlife* in their natural habitat and should also consult applicable Local RPAS laws and regulations. On top of these, any encounter between the COTS-RPAS and wildlife should be carefully executed in order to have minimum disturbance to the latter (i.e., COTS-RPAS maintains a safe distance, careful COTS-RPAS aerial maneuvers).

In this research, the main tool used is the COTS-RPAS operating on both the micro and meso scales. The micro scale features raptor behaviors such as preening, feeding, play, rousing, mating, among others. The meso scale then contextualizes this behavior in the immediate environment and acts as a force multiplier in terms of the avian survey, providing real-time aerial imagery of larger tracts of terrain. The meso scale environment includes place learning information, biodiversity information, threats, and opportunities for the raptor species, among others. Two COTS-RPAS were used in the research. What I will emphasize is the lightweight and compact size of these two COTS-RPAS. Released in 2018, the Mavic Pro 2 take-off weight is less

than 1 kilogram. Released in 2020, the Mavic Mini 2 take-off weight is a quarter of a kilo or 250 grams. When fully charged, both COTS-RPAS have approximately 30 minutes of loiter time. The size of an adult Kali bird length averages between 43 to 51 cm (wingspan likely at 100-125 cm). The Kali seems bigger in size on a one-to-one scale with the COTS-RPAS. Arguably, the COTS-RPAS appears like a smaller bird to the Kali. The Mini 2 perhaps appears pigeon-sized, having a width of 29 cm and a length of 23 cm inclusive of the propeller blades (individual blade length at 5.2 cm, width at 1.75 cm at the widest part). The Mavic 2 perhaps appears crow-sized, with a width of 48 cm and a length of 44 cm inclusive of the propeller blades (individual blade length at 11 cm, width at 2 cm at the widest part). I argue that the COTS-RPAS appears non-threatening, especially if careful aerial maneuvers are undertaken during contact. Some Kali juveniles are even documented flying closer to COTS-RPAS out of curiosity (i.e., 23 October 2022 at Virac, Catanduanes Island). On other occasions, the same COTS-RPAS were also able to document smaller avian species like Collared kingfishers (*Todiramphus chloris*), Common sandpipers (*Actitis hypoleucos*), Grey wagtails (*Motacilla cinerea*), Blue-tailed bee-eaters (*Merops philippinus*), to name a few.

There are strengths, weaknesses, opportunities, and threats, or SWOT analysis, on the use of COTS-RPAS in species monitoring. In summary, the debate has centered on the disturbance introduced by the mechanical nature of a drone (see Mulero-Pázmány Margarita, Susanne Jenni-Eiermann, Nicolas Strebel, Thomas Sattler, Juan José Negro, Zulima Tablado 2017). This is true for earlier, heavier RPAS, but arguably, this has been largely mitigated with the advent of COTS-RPAS. The introduction of the Mavic Pro 2 and Mavic Mini 2 in 2018 and 2020, respectively, features a reduction in rotor blade noise as well as an overall improved imagery payload with zoom and battery capacity. While both models can be zoomed digitally (cropping the existing display size, pixels), it should be emphasized that optical zoom (where the lens mechanically zooms in to the area of interest or object of interest), when it is available in similar compact COTS-RPAS, would be even better. Overall, the strengths outweigh the weaknesses, and the opportunities outweigh the threats with the availability of the compact COTS-RPAS.

As early as 2015, three years before the advent of COTS-RPAS, the potential of COTS-RPAS in behavioral studies had already been pointed out by Linchant et al. As early as 2012, the utility of light COTS-RPAS for field ornithologists working in difficult-to-access areas was pointed out by Sarda-Palomera et al. Sarda-Palomera et al. commented that,

> "...UAVs are just a new tool that opens new perspectives about data collection. At the end, the user must be who decides when and how to apply it according to scientific objectives, field conditions, and the sort of the level of detail and kind of information required..." (2018:6).

Indeed, later that year, the Mavic 2 Pro was introduced. Mulero-Pázmány et al. say that "...the careful use of COTS-RPAS might be a valuable alternative for methods such as bio-logging, on-foot, and manned aircraft censuses used in biological studies..." (2017:8). As I have argued earlier, the COTS-RPAS allows us to access the meso scale and microscale, and in a multiscalar platform, the mesoscale allows us to cover vast tracks of terrain that would have taken longer using transect methods.

Results/Discussion

While the package itself is non-threatening to the Kali, it is important to emphasize that skillset and training will play a vital role in making the encounter safe and successful. The operator of the COTS-RPAS should mitigate disturbance by maintaining a safe distance, maneuvering carefully in the air, and advancing very slowly in small increments.

New Observational Perspectives of the Bird: the Near Orthogonal and Orthogonal

The use of COTS-RPAS opens a new window or point of view (POV) to avian observational and behavioral studies, especially because we are now given horizontal near orthogonal and orthogonal views of the avian species while in flight. Most documentation of birds in flight typically shows the underwing and underbody parts, but now, with the aid of COTS-RPAS, we see the upper wing and upper body while in flight. When documenting in such a position, it is important to maintain safe distances of in excess of 20 meters Euclidean distance from the Kali.

See Figure 3, where a horizontal to near orthogonal view of the Kali is afforded. Note that there is a safe distance between the COTS-RPAS and the Kali. The zoom function is enabled in situ or can be done postproduction. It was also common for the author to see inquisitive flybys of the Kali near the COTS-RPAS. This is especially seen with the juveniles. The Kali will

double back and fly towards the COTS-RPAS. When such behavior is noticed, the COTS-RPAS must remain stationary and will simply pan its camera to follow the Kali.

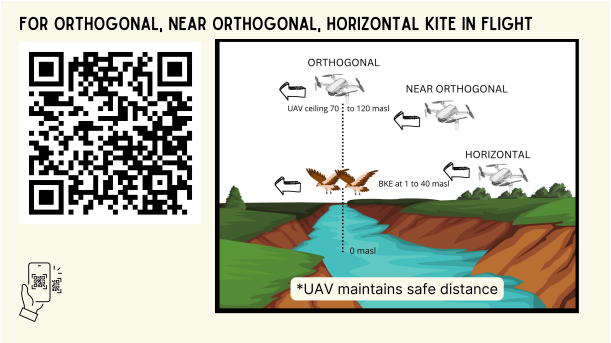

Figure 3. Compact UAS position documenting a Kali in flight. The remote sensing platform now gives access to orthogonal and near orthogonal views of the raptor.

The Kali are often seen perched on trees or bamboos, and in such a setting, the COTS-RPAS will approach the Kali very slowly and in small increments. If panicked or threatened movements are observed, the COTS-RPAS will stop at its position and remain stationary. The operator should re-assess whether to proceed if the behavior improves and back away if it deteriorates further. If the Kali's behavior has improved, proceed very slowly until approximately the 20-meter checkpoint, at which distance the COTS-RPAS zoom function can be engaged (if available). If there is a positive or neutral response, you may proceed even closer than 20 meters. In breaking the engagement, the COTS-RPAS backs up slowly and increases altitude in a clear airspace; otherwise, the COTS-RPAS will do an about-turn and exit slowly from the scene. Here is Figure 4, wherein the COTS-RPAS documents perched Kali.

Figure 4. Perched Kali and the position of a compact RPAS. Typical raptor behaviors observed at this position include grooming, preening, sunning, eating, and calling.

Observed Behaviors of the Brahminy Kite using Compact COTS-RPAS

What was just presented are some of the important guidelines for initiating the encounter with the Kali. There may be case-to-case variability, however, and there is an important rule also to avoid at all costs approaching nesting sites since the Kali pair may try to protect their nestlings or eggs from the COTS-RPAS. Once again, you may refer to Bird Watching Guidelines (Technical Guidelines 2017 No. 2). It is important to carefully assess the situation, always considering how to minimize disturbance to the Kali.

Emphasis is once again given to the need for training and accumulated flight hours. The careful maneuvers that have been proposed translate to using up most of the RPA battery before a good distance within zoom range is achieved. It is important to be able to estimate and balance the opportunity versus the current conditions of the Kali, the COTS-RPAS, and the immediate vicinity of the encounter. This is where training and accumulated flight hours matter.

Overall, the researcher was able to collect data on Kali behavior. What follows are highlights of some that were observed through the COTS-RPAS. Figure 5 is footage of a group of Kali taking turns to tap a floating object on the water. This is possibly a fishing-skill enculturation process that has been documented. Another interesting behavior is shown in footage of a Kali initiating a Split S aerial maneuver to surprise an older Kali behind the back. The subadult is moving towards an adult who is at a lower altitude. At the right timing, the subadult executes a 180-degree roll followed by a half loop with a precision-timed level exit exactly at the back of the adult. The contact causes them to spin momentarily,

but they both recover and head towards the original direction of the adult.

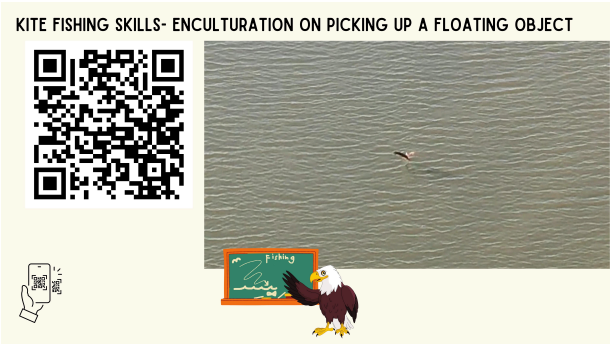

Figure 5. Possible Kali fishing skills enculturation (Frame from video by author DJI Mavic 2 Mini). The documentation of this behavior shows the brood (adults and juveniles) circling the floating object and coordinating turns to tap the object.

The author also witnessed a Kali food pass. This behavior is commonly observed among raptor parents who take turns foraging for food for their nestlings. The first Kali picks up the fish from the river, then meets the partner head-on; the partner executes a pitchback and tails behind to snatch the fish midair in the middle of the pass (see Figure 6).

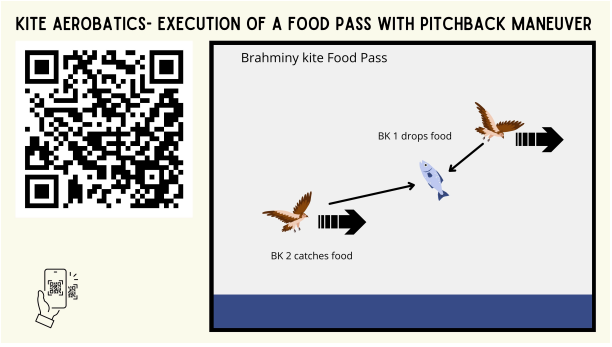

Figure 6. A pair of Kali (possibly parents with nestlings) executing a food pass.

There are also several occasions wherein Kali were documented fishing and feeding. On one occasion, a Kali was eating her/his meal in the company of four migratory Grey herons, who were nonchalant as well to the COTS-RPAS. Kali grooming was also commonly documented. Several footages show the Kali seemingly cleaning her/his beak after a meal.

Another spectacular display that was remotely sensed by the COTS-RPAS is a series of play behaviors among Kali. See Figure 7 to watch a video of two Kali engaging in aerial acrobatics and synchronized flight patterns.

Figure 7. A pair of Kali possibly engaging in courtship aerial maneuvers (Frame from video by author using DJI Mavic 2 Pro).

Finally, another advantage of the COTS-RPAS is the ability to document the raptor's place-learning skillset (see Gibson 1979 on affordances), specifically the choice of hiding places from what they perceive as threats, specifically humans. Interestingly, the Kali will spend time perched in hidden places that are hard to access on foot but easy to access for the COTS-RPAS. In one instance, two juvenile Kali were sunning while perched on a reclining bamboo stalk high from the ground, bordered by a cliff to its south and walls of tall bamboo on its other flanks. This location is indeed a refuge and a perfect hiding place. Indeed, remote sensing technology has made formerly inaccessible environments within reach (i.e., see Ghaderizadeh, Abbasi-Moghadam, Sharifi, Tariq, and Qin 2022).

Conclusion

The introduction of compact COTS-RPAS, specifically the Mavic 2 Pro and Mavic Mini 2 in 2018 and 2020, has introduced COTS-RPAS platforms that have reduced mechanical noise or rotor blade noise, as well as improved imaging payload and flight loiter time. Their ready availability and relative affordability also put newer tools and methods within the reach of scientists, researchers, and citizen scientists. These innovations address many of the issues pointed out previously (i.e., see Linchant et al. 2015) about the weaknesses and threats of using COTS-RPAS in ornithology. The compact COTS-RPAS itself appears as a "little bird" and is non-threatening to the Kali. The technology, if and

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only if (iff) combined with the right training and skillset, indeed promises plenty of opportunities in behavioral studies. It is important to be able to estimate and balance the remote sensing opportunity versus the on-site conditions of the Kali, the condition of the COTS-RPAS, and the immediate vicinity of the encounter (i.e., weather conditions). Perhaps, this is where training and accumulated flight hours matter.

In wrapping up the paper, Fisher and Hicks, writing in 2006, say about the Kali that,

> The striking Asian raptor occurs throughout the islands ...where it can be seen either perched on a tall tree or soaring high in the air. It has been heavily persecuted, especially for the pet trade.

Even in the 2019 publication of the DENR-BMB, the Kali has been listed as illegally traded and threatened, especially the juveniles. This paper, together with the blog Eco Woke SEA, wants to generate concern for the conservation and protection of the Kali in its natural habitat. There is much more to learn about this fascinating raptor or bird of prey. We have to protect them for the appreciation of our children and later generations.

Another threat to the Kali is the problem of deforestation, with data showing that the forested area in the Philippines between 1575 and 2015 was greatly reduced from 27.5 million hectares to just 7.01 million hectares in 2015 (La Vina, Carnivel, Reyes 2021). At a more localized level, deforestation per se is not the only issue; it is the fragmentation of whole forest systems into micro forest patches. These micro forest patches will not be able to support biodiverse ecosystems compared to continuous forest wholes. In one La Union watershed alone, the data show that forest reduction was 96.4% over the last 28 years (Ramirez et al 2019: 10, 13). Addressing this issue will tackle United Nations Sustainable Development Goal-15 (SDG 15). SDG 15 beckons us to look for solutions to deforestation and its corresponding destructive outcome of biodiversity loss, keeping in mind that the mere presence of raptors out in the wild beckons the presence of biodiverse ecosystems.

Secondary Analysis

The preceding is preliminary and does not presuppose that it is a comprehensive study of the Kali's behavior. What is important to highlight now are the new horizons in raptor observational and behavior studies that the technology of compact COTS-RPAS has to offer not only to scientists and researchers but also to citizen scientists (i.e., political ecology). A follow-up longitudinal, diachronic study that may be undertaken further is to conduct a survey on the acceptance of the end users (scientists and researchers, but also citizen scientists, etc.) of compact COTS-RPAS. What is the acceptance behavior towards compact COTS-RPAS? What is the perceived usefulness and perceived ease of use of compact COTS-RPAS (Venkatesh, Thong, Xu 2012; Davis 1989; Davis, Bagozzi, Warshaw 1989)?

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Statement

This observational study complies with Technical Bulletin No. 2017-02, Bird Watching Guidelines issued by the Department of Environment and Natural Resources Biodiversity Management Bureau (Non-commercial) (https://elibrary.bmb.gov.ph/elibrary/books/birding-guidelines-in-the-philippines-technical-bulletin-no-2017-02/) and the RPAS laws of the Civil Aviation Authority of the Philippines (https://caap.gov.ph/rpas-regulation/). Competing interests: The author declares there are no competing interests. Funding: WorldView 2 Satellite imagery was provided free of charge by the DigitalGlobe Foundation. All data are available for access in the personal blog/science blog https://www.facebook.com/ecowokesea/

Dataset

Canilao, Michael Armand P. 2022. Eco Woke SEA: Pagsaliksisk sa sinerhiya ng Kultura at Kalikasan [exploring the synergy of culture and nature] [COTS UAS post-processed video]. Data repository. https://www.facebook.com/ecowokesea/

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Declarations

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