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Initial application of bio-logging techniques on captive Milky Stork (*Mycteria cinerea*) in Malaysia

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Abstract: The use of remote sensing equipment on animals (i.e. bio-logging) is increasingly being used to understand numerous variables about their life at very fine temporal scales. While bio-logging has been used extensively in seabirds, it has only been used minimally in freshwater birds. Given the relatively new development of this technology, we conducted a preliminary study to understand the behavior of captive Milky Storks (*Mycteria cinerea*) using digital data loggers between 2009 and 2010 in Zoo Negara, Malaysia. Data loggers were attached to seven individuals to record axes of acceleration of movements and temperature as part of a study to develop the appropriate techniques for data logger use with this species. The birds' activities were also recorded by direct observations to assist in interpreting the output from the loggers. Detailed routine activities along with the temperature of the surrounding environment were obtained in this study. This includes normal activity such as flying, preening, roosting and aggressive displays such as the clattering threat and the anxiety stretch. With some adjustment, the study can be repeated in the wild to study the birds' detailed behaviour and ecological information on their surroundings.

Resumen: La colocación de equipo de percepción remota en animales (lo que se conoce como biomonitoreo automatizado) se usa cada vez más para entender numerosas variables sobre su vida a escalas temporales muy finas. El biomonitoreo automatizado ha sido usado extensamente en aves marinas pero muy poco en aves dulceacuícolas. Dado el desarrollo relativamente nuevo de esta tecnología, realizamos un estudio preliminar para entender el comportamiento del tántalo malayo (Mycteria cinerea) en cautiverio usando almacenadores digitales de datos entre 2009 y 2010 en el Zoológico Negara, Malasia. Los almacenadores digitales de datos fueron colocados en siete individuos para registrar ejes de aceleración de los movimientos y su temperatura, como parte de un estudio cuya meta es desarrollar las técnicas apropiadas para el uso de almacenadores automáticos de datos en esta especie. Las actividades de las aves también fueron registradas por medio de observaciones directas como ayuda para interpretar la información arrojada por los almacenadores. El estudio permitió obtener las actividades rutinarias detalladas y la temperatura ambiental. Esto incluye actividades normales como el vuelo, el acicalado del plumaje, el perchado y los despliegues agresivos como la amenazas traqueteante y el estiramiento por ansiedad. Con algunos ajustes, el estudio puede ser repetido en condiciones naturales para estudiar el comportamiento detallado de las aves y obtener información ecológica sobre su entorno.

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Resumo: O equipamento de detecção remota (i.e bio-sensores) em animais tem vindo a ser crescentemente utilizado para compreender numerosas variáveis sobre sua vida numa escala temporal bastante fina. Enquanto os bio-sensores têm sido extensivamente utilizados nas aves marinhas, eles têm sido usados minimamente nas aves de água doce. Dado o relativamente recente desenvolvimento desta tecnologia, conduziu-se um estudo preliminar para compreender o comportamento da cegonha branca (Mycteria cinerea) usando registadores de dados digitais entre 2009 e 2010 no Jardim Zoológico de Negara, Malásia. Os registadores de dados foram fixados em sete espécimes para registar os eixos de aceleração dos movimentos e temperatura como parte do estudo de desenvolvimento de técnicas apropriadas para o uso de registadores de dados nesta espécie. As atividades das aves foram também registadas por observações diretas para assistir à interpretação do output dos registadores. Neste estudo obtiveram-se as atividades detalhadas de rotina juntamente com a temperatura do ambiente circundante. Estiveram aqui incluídas atividades normais como o voo, alisamento das penas, locais de descanso noturno e exibições agressivas tal como o bater de bico e os movimentos de extensão como manifestação de ansiedade. Com alguns ajustamentos, o estudo pode ser repetido no ambiente natural para estudar o comportamento detalhado das aves e informação ecológica do ambiente circundante.

Key words: Bio-logging, bird, behavioral studies, captive, Milky Stork, *Mycteria cinerea*.

The attachment of remote sensing equipment on animals to measure multiple behavioral, physiological, and movement variables at time intervals as short as every few seconds is a relatively new form of telemetry called bio-logging (Kooyman 2004; Naito 2004; Ropert-Coudert & Wilson 2005). Bio-logging is used to collect data on a wide variety of animals, including on marine, high altitude, nocturnal, fossorial, highly mobile and small animals that previously were difficult to monitor (Davis 2008). For instance, bio-logging provides the ability to monitor animals in challenging systems, such as dense forests where it is difficult to monitor by direct observation or radio telemetry.

Seabirds have been viewed as excellent carriers of sophisticated remote sensing equipment to gather valuable data of the environment. In fact, seabirds were the most studied species in bio-logging research while their fresh water counterparts remained the least studied (Ropert-Coudert *et al.* 2009). The attention received by seabirds could be related to the fact that bio-logging science has advanced much more in marine systems. However, considering that many fresh water birds are threatened and endangered, there is a great need to conduct bio-logging studies on these species.

Many fresh water birds like the Painted Stork (*Mycteria leucocephala*) and Milky Stork *(Mycteria cinerea)* are threatened in Malaysia. Their populations are rapidly declining, yet important information to conserve them is lacking, especially in their natural habitats. A complete understanding of the behaviors, habitat utilization and their daily challenges of these stork species are needed in order to develop appropriate conservation measures. As such, bio-logging offers an important tool to increase our knowledge on storks and other fresh water birds.

The global status of the Milky Stork is listed as vulnerable due to its rapid worldwide population decline (Birdlife International 2010). In Malaysia alone, the population has critically declined since the late 1980s with more than 90 % of the wild population lost (Li *et al.* 2006). Moreover, recent observations conducted in two of its important area in Pulau Kelumpang and Pulau Terung in 2009 show that only five individuals were recorded in the area (Ismail *et al.* 2010). However, current efforts to conserve the Milky Stork rely on insufficient data about the birds' behaviour and ecology. A preliminary study of Milky Stork's behavior using bio-logging was done in Zoo Negara in 2009 and 2010 to assess their daily routine behaviors and surrounding ecological parameters. This first attempt using captive bred Milky Stork in Zoo Negara is to develop a long-term monitoring

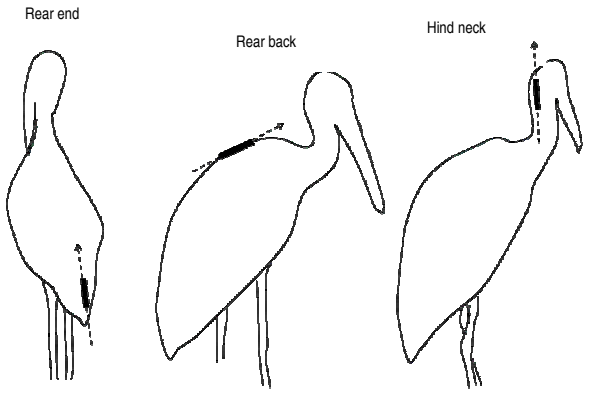

Fig. 1. The different possible position of logger attachment on the Milky Stork.

study using bio-logging techniques on birds in their natural habitat. The specific objectives are to: (1) identify and develop the correct techniques for using micro digital loggers on Milky Storks; and to (2) calibrate the data logger system to allow the remote identification of key behaviors of captive Milky Storks.

Data loggers (Model M190L-D2GT, Little Leonardo Corp.) were attached to seven individual Milky Storks, varying from two to four years of age, and then the storks were transferred to a cage (4.0 m × 5.8 m × 12.3 m) for 24 h. This period of captivity was to: (1) identify the best placement or position for the logger; (2) test the effectiveness of the logger attachment; and (3) allow the birds to adjust to the presence of the logger. Keeping the birds in captivity during this time is very important as it determines the overall success of the study, particularly during the actual release of the birds in a semi-wild environment. The logger was placed on several parts of the birds' bodies, including the hind neck, the mantle and the rump (Fig. 1). Each position was tested at least on two different individuals in the same location (i.e. rear end, rear back and hind neck).

Each logger comes in a standard size of 15 × 53 mm (diameter × length) and weighs about 18 g, which is less than 1 % of the Milky Stork total body mass (average mass = 27.6 kg). The loggers record the lateral (x) and gravity (g), also referred to as longitudinal (y), axes accelerations as well as temperature (°C). The acceleration patterns were sampled at 32 Hz and ambient temperature at 1 Hz for about 30 h. Flying behavior and foraging behavior appear as a high frequency surge signal and lowered body pitch angle, respectively. The accelerometers were glued and released using the miniaturized timer and explosive releaser from the birds. The birds were then released into a semi-enclosed area of 358 m^2 located within the Zoo Negara in Hulu Kelang, Selangor (3° 12' 32.95" N, 101° 45' 24.51" E), 19 km from the centre of Kuala Lumpur. The birds' activities were recorded for a minimum of 24 h in which the timer on the logger can be set to self-release. A simple buoyancy system was also attached to the logger to act as positioning indicator if the logger sank into the lakes or ponds in the area. After about 30 h, the timer in the logger was activated and released the logger. Thus the full daily cycle of the birds' behavior was recorded. After the logger data was transferred and analyzed, together with the data from field observation and video recordings, the Milky Stork behaviors were grouped into walking, flying, preening, aggressive displays and roosting.

Milky Storks spent most of their time roosting (45 % of the time recorded), followed by foraging (30 %), preening (15 %) and others (10 %). Tactile foraging was the most commonly used foraging method (> 70 %), which is probably due to the small size of the open water area (39 m^2) that is available as the water surface becomes murky due to foraging intensity of the storks and, therefore, the visibility of prey is compromised. The first five hours of data revealed that the data logger at the back of the birds' body is more reliable to interpret their activities after release (Fig. 2). Each type of activity had different ranges of dominant amplitude and cycles. For example, flight behavior can be identified by its dominant amplitude of more than 1 ms^{-2} with a dominant cycle of less than 0.6 second for the y axis acceleration. Further analysis and comparison of the best positions for logger attachment are yet to be reported as more data are needed before a sound conclusion can be made. As soon as the birds were released, abrupt and rapid axes acceleration can be observed in the logger record for at least 75 seconds. These axes accelerations show that the agitated bird tried to avoid nearby humans by moving away from them. Likewise, another time series of the accelerations clearly corresponded to the aggressive display of the clattering threat and anxiety stretch, which is a form of self-defense against potential threats. Other behaviors were interpreted from the logger record by comparing it with field observations and video recordings, allowing an accurate calibration of the data logger record with the behavior of the Milky Storks.

The first five hours of field observation also revealed that the birds were nervous after being exposed to their new environment and tried to mix

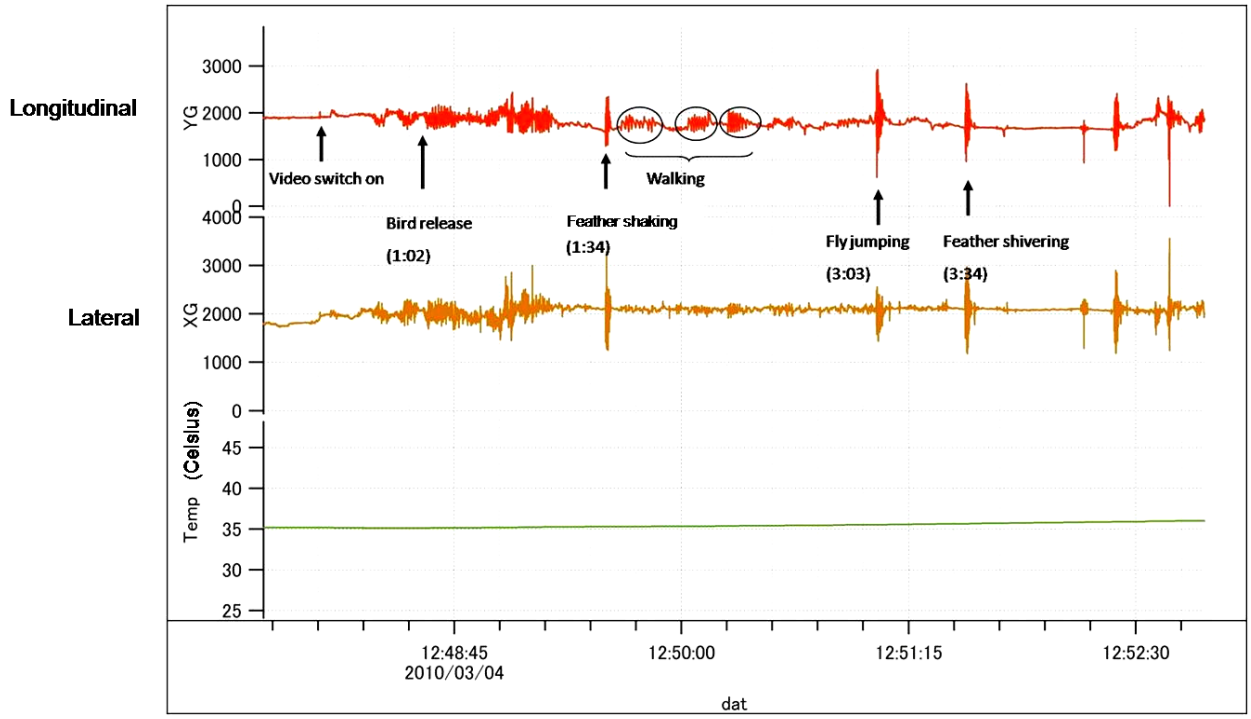

Fig. 2. Example of data recorded using the digital logger attached to rear back of the Milky Stork body.

with the group of storks in the area. They then adjusted to the new terrain or habitat, explaining the logger's record during the process. Data records from the logger, coupled with key observations on the field are, therefore, important to interpret and explain the stork's behavior as integrated information. Moreover, the behaviors recorded allowed the development of an algorithm for data compression which will help in the establishment of a long-term monitoring via this bio-logger system.

There were several problems encountered during the study, some of which might delay and put a halt to the test conducted. As this was the first attempt to study Milky Stork behavior using a bio-logging technique, many more adjustments and improvements need to be done. These include improving the handling techniques used during logger deployment and the attachment process, confirming the best logger position on the bird's body, ensuring logger recovery, monitoring of the birds' activities, understanding how the birds' preening behavior may affect long-term secure placement of the loggers and the design of data logger and its recording capacity. Regardless, this preliminary study has opened new opportunities for more advanced research related to wild birds in Malaysia. The information gathered in this study also highlights the considerable potential of bio-logging in studying endangered species such as the Milky Stork.

In conclusion, bio-logging is increasingly being used as a tool for studying the life of various animals which previously required lengthy periods of field observations in the subjects' natural habitat. This preliminary study on the Milky Stork carried out in Zoo Negara gives insight on the usefulness of the bio-logger approach as a practical solution to the challenges of studying highly mobile animals, such as water birds in their natural environments. In this study, the detailed routine activities of the threatened Milky Stork along with several ecological parameters were clearly identified using the bio-logging technique. With some adjustment, this methodology can be replicated in the wild to study the birds' behavior and to collect ecological information on their surroundings. The information would be very useful in the conservation of the Milky Stork and other endangered wild birds.

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