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A novel method for photo-identification of sea turtles using scale patterns on the front flippers

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ABSTRACT

Photo-identification using animals' natural markings is a cheaper and less impactful alternative to the use of more conventional external or internal tags for identifying individual animals. Photo-ID has already been successfully employed to monitor hard-shelled sea turtles, specifically using facial scales. However, photographing facial features might cause stress on photosensitive sea turtles, especially at night. Considering that there are more scales on the flippers than on the face and flipper photography is likely to be less invasive, we proposed an alternative method for photo-identification using the scale patterns on the front flippers. This method might also be suitable for successful photo-identification of hatchlings – which has been ineffectual using facial scales. To test the suitability of using the front flippers for photo-ID sea turtles, we took photos of the right flippers of adult and hatchling green turtles (*Chelonia mydas*) and olive ridley turtles (*Lepidochelys olivacea*) from Cabuyal, Costa Rica. The photos were analysed using APHIS, which delimits an area of interest with three reference points and then uses several additional points within this area to mark the intersections between scales. In both species, hatchlings and adults were correctly identified 92.9% and 81.8% of the time respectively but the capability of APHIS to correctly identify individuals was highly dependent on the quality of the photo. We detected similarities in flipper scale pattern between hatchlings of the same species but not between hatchlings from the same nest, indicating that hatchlings have unique flipper markings. The use of flipper scale patterns to identify individual sea turtles is comparable to the use of facial scales, without the risk of disturbing nesting females. Additionally, we were able to reliably identify individual hatchlings, which has not been possible using facial scales or conventional tagging techniques. Flipper scale patterns may potentially be a new methodology for identifying hatchlings both short- and long-term. We discuss the benefits and limitations of using sea turtle flipper scale patterns for identification as well as the benefits and limitation of APHIS.

1. Introduction

Mark-recapture studies have been used to reveal an incredible wealth of information concerning population dynamics, animal behaviour, and life-history patterns (Lettink and Armstrong, 2003; Mcmahon et al., 2007; Whitehead et al., 2000). To be successful, such mark-recapture depends on being able to accurately identify individual animals on subsequent re-encounters. External tagging has been the most common technique used to identify individuals (Oosthuizen et al., 2010), however, tags can be lost, damaged and/or bio-fouled (Limpus, 1992; Reisser et al., 2008). Internal tags, such as Passive Integrated Transponders (PIT) (Gibbons and Andrews, 2004) also have their own pros and cons. For example, internal tags tend to have higher retention rates but they can be expensive and require a specific reader (McDonald and Dutton, 1996; Schofield et al., 2008).

An alternative to tagging is to use animals' natural markings to distinguish between individuals. Natural markings have the advantage of being potentially an almost indefinite form of identification (Carpentier et al., 2016) and can be readily recorded by almost anyone with a camera. They also have the benefit that animals can be identified from afar and without capture, making them less disruptive and suitable for use in species that are hard to tag (Frisch and Hobbs, 2007). Photo identification has already been successful in a wide range of taxa, including whales (Katona and Whitehead, 1981; Whitehead et al.,

Abbreviations: APHIS, Automated Photo-identification Suite

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1990), frogs (Bradfield, 2004), bobcats (Heilbrun et al., 2003), horses (Dawson and Miller, 2008), snakes (Albu et al., 2008) and lizards (Sacchi et al., 2010).

In sea turtles, leatherback turtles (*Dermochelys coriacea*) have been identified using photographs of their pineal gland (Buonantony, 2008; Dutton et al., 2005), while green turtles (*Chelonia mydas*), loggerhead turtles (*Caretta caretta*), and hawksbill turtles (*Eretmochelys imbricata*) are commonly identified in-water using their facial scales (Dunbar et al., 2014; Reisser et al., 2008; Schofield et al., 2008). (Schofield et al., 2008) used these facial scales to re-identify individual loggerhead turtles 3 to 5 years after the initial photograph while (Carpentier et al., 2016) validated that the technique can be suitable for monitoring individuals for lengths of time extending up to 11 years. Despite this technique being highly valuable, photographing the head or face of a turtle may be disruptive or stressful, especially those encountered at night on nesting beaches (Witherington, 1992). Turtle flippers have the added advantage of having more scales, which increases the number of unique connections and patterns for identification purposes.

Here, we evaluated for the first-time whether the scutes on the front flippers can be a practical alternative to facial scutes for photo-ID. We analysed scale patterns on the front right flippers of olive ridley (*Lepidochelys olivacea*) and green turtles to identify adults and hatchlings. We also evaluated whether hatchlings from the same nest had similar scale patterns to their immediate siblings or whether individuals of the same species had similar scale patterns. Since scute patterns could change as turtles grow, adult and hatchling scute patterns were tested together. A secondary objective was to test the reliability and accuracy of APHIS (Automated Photo-Identification Suite, freely available at http://www.imedea.uib-csic.es/bc/ecopob/ - accessed 22/3/18) ((Óscar et al., 2015) in identifying individual sea turtles using scale patterns.

2. Materials and methods

2.1. Photo collection

We took photos of the front right flipper of nesting turtles during night-time patrols conducted on Cabuyal in northwest Costa Rica. Turtles were approached after egg laying had commenced. At this point, a photo of the flipper was taken under red light. Photos were taken in black and white due to the red light distorting and blurring the photo when taken in colour. Flash photography was not used to minimise stress to the animal. Photos were taken at a distance of approximately 50–100 cm using a Panasonic Lumix DMC-FT1 camera (Panasonic, Osaka, Japan). The entire flipper was always photographed to ensure that area of interest was always captured. APHIS could then be used to zoom in and highlight the area of interest. Photos were never taken after the female had commenced covering or camouflaging the nest. None of the females that were photographed aborted nesting as a result of the light or camera.

Hatchlings were opportunistically encountered during daytime beach patrols. Hatchlings were held with their right, front flipper extended for photographing. Black and white photos were taken 5-10 cm from the flipper, without a flash and under natural sunlight. Hatchlings were held for less than a minute while being photographed, and were released shortly after sunset.

11 green turtles of the 22 that nested in the season and 3 olive ridley turtles were included in the analysis. 69 green turtle hatchlings and 41 olive ridley hatchlings from 3 and 2 nests respectively, were included in the analysis (Table 1).

We removed photos that were blurry, glary or the flipper was at an angle that made accurate marking of the reference points impossible. However, some blurry photos could be marked and analysed so they were included in a second round of analysis (Table 1).

Table 1
The number of comparison photos, database photos and total photos taken for adults and hatchlings.

	Green turtles	Olive ridley turtles	Total
Adults			
Database photos	11	3	14
Comparison photos	9	2	11
Number of adult turtles that provided comparison photos	5	1	6
Hatchlings			
Database photos	69	41	110
Number of nests photographed	3	2	5
Comparison photos (no blurry photos)	14	11	25
Comparison photos (blurry photos included)	16	17	33

2.2. Database and comparison photos

At least one initial photo must be entered into APHIS in order for the program to be able to compare subsequent photos. Therefore, an initial photo of each individual turtle (both hatchlings and adults) was entered into APHIS before any comparisons could be made. These photos will be henceforth referred to as 'database photos' as they are the photos already input into the system, which APHIS uses as a reference when matching new photos.

Any additional photos entered into APHIS in order to determine the effectiveness of APHIS at identifying individual sea turtles will be henceforth referred to as 'comparison photos'.

Comparison photos can be saved in APHIS after analysis thereby allowing them to become database photos. This allows APHIS to accumulate multiple photos for each individual over time. However, after each analysis we did not save comparison photos meaning that all analyses only involve one database photo for each individual turtle.

Some turtles had multiple photos that could be used as database photos. We selected the best photo to be the database photo and used the remaining photos as comparison photos. This resulted in there being more comparison photos than database photos and in some turtles having multiple photos used as comparison photos (Table 1).

2.3. Preparing photos for analysis in APHIS

2.3.1. Defining the area of interest

Flipper photographs were easily uploaded into APHIS for analysis. We used the I^3S approach (http://www.reijns.com/i3s/), which involves defining the area of interest by assigning three clearly identifiable reference points and then marking individual points within this area. The three reference points that we selected are easily identified on all sea turtles with scales on their flippers. By taking a photo of the entire flipper, anyone can reliably take a photo that can be used to identify individual turtles. Photos in the field were taken by the project's trained biologists. We chose three points that were easily identifiable and could be repeatedly and reliably marked on both hatchling and adult turtles. The three points were: (1) the join between the two most proximal thickened scales (closest to the axilla) on the posterior edge of the flipper, (2) the point directly anterior to the first point on the flipper and (3) the area where the thickened scales most distal from the axilla, on the trailing edge of the flipper, join with the non-thickened scales (Fig. 1). The second reference point was the most difficult to place as it is the least distinguishable. To ensure the reliable placement of this point, we used a ruler to trace a straight line along the join between the first and second thickened scale to the leading edge of the flipper. If the line intersected a join between scales, we used that as the reference point; otherwise, we used the first join to the right of the line (Fig. 2).