Photo-identification method for green and hawksbill turtles - First results from Reunion

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Introduction

The identification of individuals within a population and the collection of reliable information on distribution, habitat use, or life history traits, are the minimum required for behavioural and ecological studies of a species. Most studies on marine turtle populations rely on standard 'capture-mark-recapture' methods based on tagging (flipper tags or Passive Integrated Transponder (PIT) tags), which is costly, induces stress to the animal, and uses tags that do not last for a lifetime (Balazs, 1999; Bellini *et al.*, 2001; Reisser *et al.*, 2008). Tags are also difficult to apply to marine animals, such as turtles, that spend most of their time on foraging grounds and at sea. For these animals, most of the 'capture-mark-recapture' studies are conducted on the beach during nesting as the females can be easily manipulated.

Conversely, photo-identification (photo-ID) relies on natural marks on the body photographically captured to identify and re-sight individuals. It can be used to complement other methods (e.g. if a tag is lost), or may eventually replace tagging (Speed *et al.*, 2007; Reisser *et al.*, 2008). This technique can also be used to quantify the period of tag attachment and tag loss and thus assist in the correction of errors in 'capture-mark-recapture' estimates (Mrosovsky & Shettleworth, 1982; van Dam & Diez, 1999). Photo-ID presents many advantages: the method is less costly, and animals are not captured physically (significantly reducing stress). However, for photo-ID techniques to work, the physical characteristics of the animal have to be stable over time, and independent of sex or age (Blackmer *et al.*, 2000; Rodriguez & Martinez, 2000; Speed *et al.*, 2007; Reisser *et al.*, 2008; Schofield *et al.*, 2008). Different photo-ID techniques have been used in monitoring of other wild animal populations (Langtimm *et al.*, 2004; Karanth *et al.*, 2006; Badford *et al.*, 2008; Gamble *et al.*, 2008; Huffard *et al.*, 2008). Most of the photo-ID methods developed for marine turtles were based on the visual comparison of the facial profile photographs according to the shape and pattern of the scutes in Chelonidae, and on the spot pattern in Dermochelidea (Richardson *et al.*, 2000; Rodriguez & Martinez, 2000; Reisser *et al.*, 2008; Schofield *et al.*, 2008).

We investigated the suitability of a new method of photo-ID based on a non-subjective and computer-assisted process using the coding of the facial profiles according to the position and the shape of the scutes using photographs. The analysis was done for green and hawksbill turtles from Reunion, Mayotte, and Mahe (Seychelles) in the Western Indian Ocean. This non-intrusive technique is of interest to researchers for identifying untagged marine turtles that cannot be caught easily in sites such as Reunion, where marine turtles forage outside the reef barrier and where nesting activity is low. The turtle population in Reunion declined dramatically after human colonisation as a result of intensive harvesting of eggs and nesting females (Dubois, 1669; Hughes, 1973; Frazier, 1975; Bertrand, 1986); however the foraging turtle population has increased over the last ten years (Jean *et al.*, accepted). Two species are regularly observed today along the coastline: the green turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*), which is less frequently observed than the first species (1/10; J. Bourjea, *pers. obs.*). Some recovery of the nesting green turtle population has been recorded since

2004 on one beach of the west coast (Ciccione & Bourjea, 2006; Ciccione *et al.*, 2008).

The photo-ID method

Our photo-ID method is based on the use of facial profile photographs of marine turtles. As each individual does not display the same scute pattern in the right and left facial profiles, both sides are used to characterise each individual whenever possible. Each facial profile is transformed by visual inspection into a code. This code describes the scutes on the turtle's head located posterior to the eye to the neck and from the line of the upper jaw to the top of the turtle's head (Figure 1). The first single digit of the code profile represents the number of scutes located immediately posterior to the eye, the post-ocular scutes. Thereafter, 3-digit code series represent each scute posterior to the eye, post-ocular scutes comprised, which share at least one scute border (Figure 1). The first number of the 3-digit code corresponds to the row number. The second number corresponds to the position of the scute in that row. And the third one corresponds to the number of sides of the scute (Figure 1). At the end, two codes composed of a 1-digit plus a series of 3-digit codes and defined for both profiles define the identity of one individual.

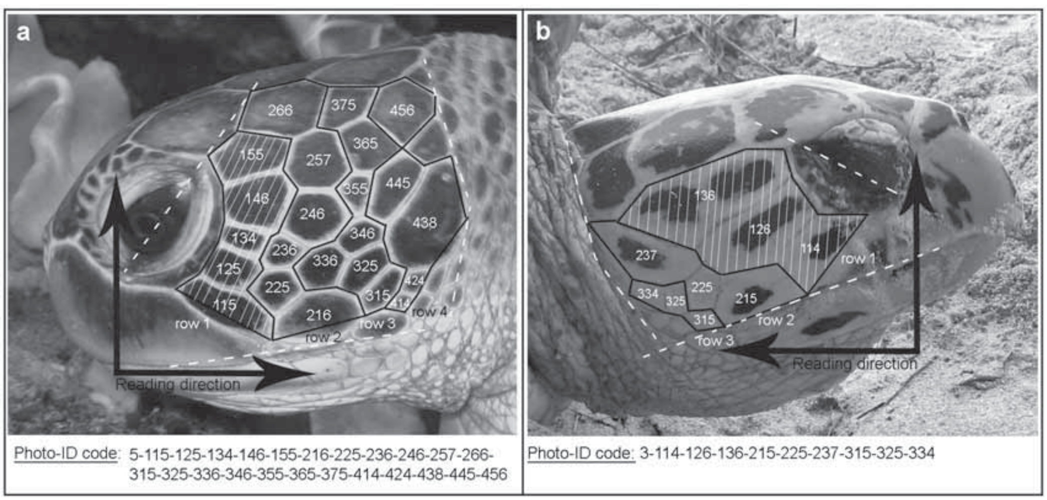

Figure 1: Coding process for a green turtle's left profile (a) and a hawksbill turtle's right profile (b) based on the position and the shape of the scutes. Limits of the profiles are indicated with white dotted lines. Post-ocular scutes (striped scutes) are located immediately posterior to the eye. Bottom-central scutes are located above the bottom limit (upper jaw).
(a) Photo: CSAL Plongée, 2008. (b) Photo: E. Talma, 2007.

We developed a MySQL database with a secured online access using both login and password to manage photographs and sighting reports. In a first step, the images converted by visual inspection or "fingerprints" are entered into the database. They are represented by the 3-digit codes of all the scutes within each profile. This step takes about two minutes per profile, when done by trained personnel. Once the image is fingerprinted, an automated search routine compares the "new" individual to the records held in the database. The system allows rapid comparison using code recognition, by basically comparing the 3-digit codes one by one, and according to other criteria (number of post-ocular scutes, species). Typically, the program searches for the most relevant code, that is the code composed of the highest number of matching 3-digit scute-codes. The larger the number of codes entered into the database, the more relevant and accurate the results will be. After the automated search is done, the 20 best matched images in the database are presented in descending order of similarity, thus reducing the number of photographs to be compared. In fact, the program selects out a set of photograph records that should be visually compared to the query image. Then, final visual comparisons of new images with those in the database establish whether a marine turtle has been sighted previously. The difference between two codes for a same photograph is mostly due to a difference in the number of sides counted for a scute (third digit of the 3-digit code). That can be explained by the quality of the picture or personal interpretation.

This recognition method was initially defined and tested on green turtles in Mayotte that were both flipper-tagged and photo-identified. A total of 14 individual green turtles were used for the validation of the method that had left and/or right profile images captured while foraging. 13 left and 12 right profile images were entered into the database, together with 28 other left and 26 other right profile images of these turtles taken at different times (Table 1). An additional 27 profiles of other green turtles photographed in Reunion were entered for the validation process as they provided additional data noise through which the program had to search. The method was similarly tested on hawksbill turtles encountered around Mahe (Seychelles) that were both flipper-tagged and photo-identified, and on untagged individuals from Reunion that were photographed two or three times when they were observed. A total of 14 individual hawksbill turtles were used for the validation of the method using left and/or right profiles captured while nesting and swimming. 12 left and 9 right profile images were entered into the database, together with 13 other left and 9 other right profile images from these individuals but taken at different times. An additional 89 profiles of other hawksbill turtles photographed in Seychelles and Reunion were entered for the validation process (Table 1).

	Chelonia mydas		***Eretmochelys imbricata***	
Total individuals*	14		14	
	Right profiles	**Left profiles**	**Right profiles**	**Left profiles**
Sightings	12	13	9	12
Re-sightings	26	28	9	13
Total	38	41	18	25
Other individuals**	12		50	
	Right profiles	**Left profiles**	**Right profiles**	**Left profiles**
Sightings	9	9	28	33
Re-sightings	2	7	12	16
Total	11	16	40	49
Total individuals	**26**		**64**	
Total profiles	**49**	**57**	**58**	**74**

Table 1: Number of individuals and profiles used for the validation tests of the photo-ID method for green and hawksbill turtles. * Tagged green turtles from Mayotte, and tagged and untagged hawksbill turtles respectively from Mahe and Reunion. ** Additional profiles entered in the database before the test: hawksbills are from Mahe (tagged and untagged) and Reunion (untagged) and greens are from Reunion (untagged).

Results

The matching tests succeeded for all the profiles for both species. The program correctly identified all the re-sightings already identified in situ by the presence of flipper tags or a series of photographs taken at the same moment. The system decreased the number of images that needed to be visually compared, to a maximum of 20 images selected from the registered data according to the input profile code. All the query profiles entered for the test matched with at least one of the top six results displayed by the system. And among the matching profiles, 94.44% profiles for greens and 78.26% profiles for hawksbills were found in the first position in the list, which revealed a better accuracy for green turtles. This variation between species appears to be related to the lower number of scutes recorded on the profile for the 14 hawksbills used (N=10.39 SD=1.63) compared to 14 greens (N=17.35 SD=2.57). This resulted in a shorter code for hawksbills made up of fewer 3-digit scute-codes, and consequently to a higher number of potentially matching profiles. For this reason, the entire profile showing all the scutes near the neck is required for hawksbill turtle photo-ID. Conversely, a wide range of photographs can be used for green turtles as long as post-ocular and bottom-central scutes (i.e. at least the two first rows) are visible. Moreover, results showed that blurred photographs could be used, as long as the separations between the scutes were visible.

Based on the validation of the green and hawksbill turtles photo-ID method, a long term programme for monitoring the marine turtle population recently started around Reunion. This programme mainly uses photographs taken by local Scuba divers in order to identify untagged individuals foraging outside the reef barrier.

The turtle photo-ID programme in Reunion currently includes nearly 150 photographs in the database captured by local Scuba divers since 2005. Based on this, we identified 60 different green turtles and 20 different hawksbill turtles observed foraging between five and 30m depth in commonly frequented diving spots. Of these, 15 green turtles and two hawksbill turtles were re-sighted two or more times in the same location, many months apart. The longest interval between the first and last observation was four years for a juvenile green turtle, encountered twice at the same diving spot located outside the reef barrier at depth of around 20m. Most of the turtles observed were juveniles or sub-adults. Our results seem to indicate foraging site fidelity behaviour in some juvenile turtles found in Reunion but this needs to be confirmed by further photo-ID or by acoustic or satellite telemetry in the future.

Conclusion

Preliminary results of the validation of the method based on 106 profiles of green and 132 profiles of hawksbill turtles, indicate that this method based on a computer-assisted screening is reliable to identify individuals within these species. However, a more robust validation using a larger number of profiles per species and a multi-observer approach to avoid observer bias has to be done in order to finalize the validation of the method. This will be done as the next step in the development of this programme.

From a practical point of view, field experiences have indicated that photo-ID may be more suited for underwater images rather than for images taken on the beach as sand may obscure parts of the head, especially with hawksbill turtles. For photographs taken on beaches, profiles should be clear of sand and washed off with seawater. One advantage for underwater fieldwork is that the entire profile is most often visible, as the head and the neck of the turtle are extended during feeding. In addition, digital technology provides easy acquisition of high-resolution images and enables photography of the turtles without going close and disturbing them.

Analyses of images showing the facial profile of marine turtles at the three study sites (Mayotte, Mahe and Reunion) have shown the effectiveness of the technique for individual identification and site fidelity studies of foraging habitats. The use of this method in Reunion, where marine turtles cannot be conventionally tagged as they stay outside the reef barrier, should considerably increase our knowledge regarding home-range and habitat use of the resident population and, coupled with aerial survey, assessment of the foraging population. On a larger geographic scale, the use of this method should contribute to study the origin of these turtles and their movements between different habitats in complement or in substitution to standard ‘capture-mark-recapture’ studies.

Photo-ID can become extremely tedious and prone to subjective errors when large catalogues of images are being processed and matched manually, thereby inducing a loss of accuracy. The technique presented here is based on a non-subjective process, with a computer-assisted sorting routine, albeit requiring personal training to assign accurate profile codes to each photograph. It allows streamlining of the search for any particular individual to a maximum of 20 images selected from the database according to the numerical correspondence of the input profile code. Unlike many automated image identification systems, which require standardized photographs with particular inclination and resolution, this method allows the use of a wide range of photographs as long as post-ocular and bottom-central scutes are visible for green turtles, and the entire profile of scutes is visible for hawksbill turtles. Special fieldwork and training for photographers is not required. The participation of scuba divers is a great opportunity to collect images over time and across a broad range of locations, allowing continuous and long-term studies. It is also a good way to increase public awareness for the conservation status of these endangered species.

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First report of *Chelonia mydas* affected by cutaneous fibropapillomatis on the West coast of Madagascar

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Located at 15 to 65 km off the shore of Maintirano, the Barren Archipelago consists of 10 small islands. All these islands are less than one km^2 in size and six of them are covered with vegetation similar to the one found on the mainland. Because of their isolation, these islands are relatively preserved and little is known about their flora and fauna. These islands also provide important reproductive and foraging habitats for marine turtles. Two of the five marine turtle species that frequent the waters around the archipelago nest on the wild beaches of these islands.

Formerly exploited by fisheries and the extraction of guano, these islands are now frequented only by Vezo fishermen, who set up their camps for periods lasting from a few days to several months. The semi-nomadic Vezo community originates from the south-west coast of Madagascar and currently populate most of the littoral zone along Madagascar's west coast between Toliara and Mahajunga.

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