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Applying a fast, effective and reliable photographic identification system for green turtles in the waters near Luichiu Island, Taiwan

Chemg-Ming Su [a], Cheng-Ting Huang [b], I-Jiunn Cheng [a,*]

[a] Institute of Marine Biology, National Taiwan Ocean University, Keelung 202-24, Taiwan, ROC
[b] Department of Agriculture, National Taiwan Ocean University, Keelung 202-24, Taiwan, ROC

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ABSTRACT

Liuchiu Island of Pengtung County, Taiwan, is the only island host both foraging and nesting green turtles. Due to almost complete overlap of in-water study with the major tourism activities—in water observation of sea turtles on the island, an effective, stable and fast, non-invasive photo-ID system has been developed to estimate the size of this population. The characteristics of facial scales, such as size, shape and arrangement are used as the diagnostic tools. One hundred and six to one hundred and forty-two turtles, with minimum 6 and maximum 8 were males have been identified based on underwater photos collected from 2011 to 2013. The right and left facial scutes of most turtles are not identical suggesting that both sides of the head must be photographed in order to determine the population size of the turtles. Based on the frequency of observation, these three to five males and forty to seventy-two females or undetermined sex were assumed to be resident while four males and sixty-six to seventy female or undetermined sex turtles were assumed to be migrants. Repeated photographed suggests that at least portion of the resident turtle conduct seasonal migration around the island. Among all sections of the area surveyed, turtles were most concentrated from Beauty Cave to Vase Stone, and least numerous from Shan-fu Fishing Port to Clam Bay. This is the first photo-ID system developed in Taiwan. It will benefit sea turtle research in the future and enhance sea turtle conservation significantly.

1. Introduction

A first step in conserving populations is to identify individual animals in order to estimate the population size (Bradshaw et al., 2007; Lusseau et al., 2006; McMahon et al., 2007; Sibly et al., 2005; Thompson et al., 2000). The mark-and-recapture technique is widely used to estimate population sizes of wild animal populations (e.g. McMahon et al., 2007; Wilson and Wilson, 1989). For sea turtle research, the most common marking method has been flipper tags. However, particularly for longer periods including migrations, accuracy is affected by factors such as tag material deterioration, different environments encountered by animals migrating on different routes, variation in care taken during labeling, tag loss due to ontogenetic changes in individual animals and inability to read the tag information (Balazs, 1982; Bellini et al., 2001; Limpus, 1992; Mrosovsky and Shettleworth, 1982; Schofield et al., 2008; Van Dam and Diez, 1999). For these reasons, the mark-recapture method is mostly used to estimate the population size based on nesting females. In addition, the application of this technique in marine environments can be influenced by topographic features, hydrodynamic regime, budget and safety, which often bias the results of investigations (Balazs, 1999; Bellini et al., 2001; Hays et al., 2010; Jean et al., 2010; Mrosovsky, 1976; Reisser et al., 2008; Schofield et al., 2008; Witzell, 1998).

Photo identification (ID) is a non-invasive individual identification technique. It uses distinct and fixed morphological characters of the animals as the keys for individual identification. Once animals are mature, morphological characteristics tend to be stable, unless the animal is injured in this region. Thus, they can be used for individual identification (Bradshaw et al., 2007; Forcada and Aguilar, 2003; Reisser et al., 2008; Schofield et al., 2008; Thompson et al., 2000). A major advantage of photo ID is that researchers do not contact the animals directly after this system is established, thus reducing interference, stress and injury in the long run (Blackmer et al., 2000; Hammond, 1990). For large wildlife that is difficult to capture and tag, such as whales, photo ID is an easier way to identify individuals than physical capture. In addition, for long-lived and migratory marine animals, such as sea turtles, photo ID can provide a long-term and very stable identification method. It can add to and even replace tag labeling, reducing the loss of research data due to missing tags (Blackmer et al., 2000; Dunbar et al., 2014; Jean et al., 2010; Reisser et al., 2008; Rodriguez and Martinez, 2000; Schofield et al., 2008; Speed et al., 2007).

The main morphological characters useful for sea turtle identification are the pattern, number, size and arrangement of facial scales. Previous studies have proved that it is very easy to photographically record and to re-identify individual turtles based on characteristic facial scales

* Corresponding author. Tel.: +886 2 24622192x5303; fax: +886 2 24628974.
E-mail address: b0107@mail.ntou.edu.tw (I.-J. Cheng).

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(Schofield et al., 2006). Furthermore, the high accuracy and durability of distinctive scale patterns allow researchers to determine population sizes, conduct behavioral analyses and determine migration patterns (Jean et al., 2010; Reisser et al., 2008; Schofield et al., 2008). For example, Schofield et al. (2008) photographed the facial scales of loggerhead sea turtles near Zakynthos Island, Greece, and developed a simple, effective and reliable individual identification system. They identified over 400 unique loggerhead turtles that frequent the island to breed each summer, and they proved with their high-quality photos that this system can guide any person in correctly identifying individual turtles. Reisser et al. (2008) also used photo ID to augment tag labeling for determining the population size of resident hawksbill and green sea turtles in Arvoredo Protected Area, Brazil. They also used photo ID to determine which individual turtles had lost tags. In recent years, Jean et al. (2010) collected facial photos of green and hawksbill sea turtles near Reunion, Mayotte and Mahe Islands in the western Indian Ocean and digitally encoded the facial characters into a computer. With powerful and fast computing capability, they were able to compare large volumes of photos and accelerate the identification processes.

Five species of sea turtles are found in Taiwan; namely green, loggerhead, hawksbill, olive ridley and leatherback sea turtles. Among them, green turtle is only species that nest in Taiwan (Cheng, 1995). Three main nesting site were identified; Wan-an Island of Penghu County, Lanyu Island of Taitung County and Liuchiu Island of Pentung County (King et al., 2013). Among three islands Liuchiu is the only island that host both foraging and nesting sites. Even though in water capture of sea turtle is legitimate with government license, it is rather infeasible in the study site. Underwater observation of green turtles in nearshore waters is a major tourist attraction for Liuchiu Island. Millions of tourists visit this island each year, resulting in almost complete overlap of in water study and tourist activities. In order to avoid conflict interests between research and tourism, photo ID becomes a compatible method to infer the population size of green turtle in the nearshore waters of Liuchiu Island.

Facial photographic images were taken from 2011 till 2013 in the nearshore waters of Liuchiu Island, and used for develop a photo identification database based on facial scute records. We used this database to infer population size and distribution of turtles on the island. We anticipate that this photo ID database will contribute towards informing conservation and management practices of the local government on the island.

2. Material and methods

2.1. Study site

Liuchiu Island (22° 19′ N, 120° 21′ E) is located approximately 14 km offshore to the south-southwest of Taiwan (King et al., 2013). Among the forty islands off Taiwan, Liuchiu is the only coral island. Its area is 6.802 km^2. The island is covered with coral limestone, and the coast is surrounded by uplifted coral reefs. The weather is warm and dry, and the water temperature is influenced by the tropical latitude and a branch of the Kuroshio. The seasonal variation of water temperature is minor; ranging from 23.7 °C in January to 29.6 °C in July (Institute of Marine Biology, Marine Ecology and Conservation Laboratory unpublished data, 2011 to 2014). Water depth is less than 20 m within 100 m distance from the shore (Wu, 2008).

2.2. Observation procedures

The observations were carried out from June 30, 2011 until July 19, 2013. In addition to intense investigations during the nesting seasons of 2011 and 2012, research was also carried out on 3- to 5-day surveys every two months during the other seasons. Surveying was done by both snorkeling and scuba diving. A CANON SLR camera, model G12 with a WP-DC24 waterproof housing, was used to photograph the right and left faces of resident green turtles. Prior to each survey, the date and survey site were recorded.

2.3. Survey section determination

Six sections around the island were chosen initially. They were (1) Beauty Cave to Vase Stone, (2) Jun-Au Beach to Lobster Cave, (3) Lobster Cave to Taipower Company, (4) Hai Mouth to Thick Stone Reef, (5) Thick Stone Reef to Daliao Fishing Port, and (6) Shan-fu Fishing Port to Clam Bay (Fig. 1).

The preliminary study showed that the surveys could be grouped into 4 instead of 6 sections. They were (I) Beauty Cave to Vase stone (red line in Fig. 1), (II) Jun-Au Beach to Taipower Company (blue line), (III) Hai Mouth to Daliao Fishing Port (black line), and (IV) Shan-fu Fishing Port to Clam Bay (green line). In each section, a zone 10 to 20 m from the shore was surveyed. The reasons for regrouping the survey sections are: (a) a commercial port lies between Vase Stone and Jun-Au Beach and between Taipower Company and Daliao Fishing Port; (b) distances from Hai Mouth to Clam Bay and from Shan-fu Fishing Port to Beauty Cave are long, with steep terrain and no access to the shore is available.

The section chosen for each survey depended on the sea conditions (current direction, tide, waves and underwater visibility) of each section and time available for survey (Table 1). The most suitable section was chosen for each survey. In cases when all sections were available, the one(s) with the fewest surveys was chosen.

2.4. Photo ID technique

The photo ID process is similar to Schofield et al. (2008) and used to classify the various morphological characters of lateral facial scales. Similarly to practice in fish taxonomy, we progressively divided the photos into smaller groups that shared more characters. Comparison and matching of photographs within each group were made by subjective observations of four different sets of facial scale group: 1. the number and size of postocular and central scales, and whether presence a scale between two scales stated above, 2. number of temporal scale, 3. number and size of tympanic scales, and 4. special facial scale arrangement. We also separate the male from female or undetermined sex. A tail extending significantly beyond the supracaudal scale indicates a male; otherwise the turtle is either a female or of undetermined sex. Detail of the identification tree refers to the supplementary online literature.

3. Results

3.1. Photo ID

Under the ideal situation, both faces of all turtles should be photographed in every occasion. However, due to limited manpower, only some were photographed on both faces, some were taken in

Table 1
The section visited in each survey and the number of survey conducted in each section per month during the study period.

month	# section/surveyed	# surveys/section/mo.
Jan	1	0.5
Feb	0	0
Mar	2	0.75
April	3	1
May	1	0.25
June	1	0.5
July	4	5.3
Aug	3	4.8
Sept	2	0.5
Oct	2	1.75
Nov	0	0
Dec	2	0.75