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The international importance of the archipelago of Cape Verde for marine turtles, in particular the loggerhead turtle *Caretta caretta*

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ABSTRACT

The shores of Cape Verde hosts one of the most important nesting populations of the loggerhead turtle *Caretta caretta* in the world, as well as important feeding grounds for hawksbill *Eretmochelys imbricata* and green turtles *Chelonia mydas*. In the past few years, a number of scientific studies have demonstrated the relevance of the waters and beaches of this archipelago for the conservation of these endangered marine megavertebrates. This article aims to bring together the most relevant scientific information published on the subject so far. In addition, we will provide an overview of the current situation of sea turtles in Cape Verde, their conservation status and their importance in an international context.

RESUMO

A costa de Cabo Verde possui uma das maiores colónias reprodutoras da tartaruga comum *Caretta caretta* no mundo, bem como uma área muito importante para a alimentação de juvenis de tartaruga de-casco-levantado *Eretmochelys imbricata* e de tartaruga verde *Chelonia mydas*. Nos últimos anos, vários estudos científicos têm demonstrado a importância das águas costeiras e das praias do arquipélago para a conservação desta megafauna marinha que se encontra em perigo de extinção. Este artigo tem por objectivo compilar as informações científicas mais relevantes que têm sido publicadas sobre o assunto até agora. Além disso, vamos tentar fornecer uma visão global da situação actual das tartarugas marinhas em Cabo Verde, seu estado de conservação e sua importância no contexto internacional.

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INTRODUCTION

Five different species of sea turtle have been observed in the Cape Verde Islands, an archipelago situated in the eastern Atlantic, *ca.* 500 km west of Senegal, West Africa: loggerhead turtle *Caretta caretta*, hawksbill turtle *Eretmochelys imbricata*, green turtle *Chelonia mydas*, olive ridley turtle *Lepidochelys olivacea* and leatherback turtle *Dermochelys coriacea* (López Jurado *et al.* 2000a). Olive ridley and leatherback migrate through the waters of the archipelago and are difficult to observe. Hawksbill and green turtle juveniles are often found feeding in neritic waters of Cape Verde. These four species do not nest in the archipelago. Loggerheads are the most common, and without any doubt, the most representative Capeverdean sea turtle. Every year, thousands of female loggerheads migrate from their feeding grounds to Cape Verde to nest and hundreds of thousands of hatchlings emerge from their nests and enter into the sea. At the beginning of their marine life, they quickly leave the coast, undertake long oceanic migrations and, after reaching sexual maturity, return to Cape Verde several years later to nest on the beaches.

Although they do not nest in the Cape Verde Islands, juvenile green and hawksbill turtles are very common and can remain feeding in shallow and protected bays for several years, migrating far away when they approach sexual maturity. Genetic studies of green turtle juveniles in the archipelago have revealed that they do not come from one single nesting population, but from different populations that are widely dispersed through the Atlantic. Over 30% of the Cape Verde feeding grounds are populated by green turtles that hatched on the American continent and undertake transatlantic migrations (Monzón Argüello *et al.* 2010c). Other juvenile green turtles come from the coasts of West Africa, Brazil and Ascension Island in the South Atlantic (Monzón Argüello *et al.* 2010c).

Results of genetic studies of hawksbill juveniles in the Cape Verde Islands indicate the existence of populations that have not yet been genetically characterized elsewhere (Monzón Argüello *et al.* 2010b), but also suggest that a small proportion of these turtles may come from the Caribbean.

THE CAPE VERDE LOGGERHEAD TURTLE

References to the presence and abundance of sea turtles in the archipelago of Cape Verde go back to the 15th century (see Lazar & Holcer 1998, López Jurado *et al.* 2000a, López Jurado 2007, Loureiro & Torrão 2008). These old texts describe the capture of turtles for meat consumption and also for alleged medical purposes. During the past decade, the nesting population of the Cape Verde loggerhead turtle became known to the scientific world thanks to the studies started by the biologist, Luis Felipe López Jurado, of the University of Las Palmas de Gran Canaria (Cabrera *et al*. 2000, Cejudo *et al*. 2000, López Jurado *et al*. 2000a, b).

Today, the loggerhead turtle nesting population of Cape Verde is considered the second largest population of this species in the Atlantic and the third worldwide, after the nesting populations in Florida and Oman (López Jurado *et al*. 2007). The presence of loggerhead turtles has been documented on all the islands in the archipelago, as well as on some of the islets, but with highly variable densities among the various islands. Around 85-90% of nesting is concentrated on the easternmost island of Boavista, where the population is currently estimated at more than 10,000 nests per year. (López Jurado *et al*. 2007, Marco *et al.* 2008, 2010). The islands of Maio, Sal and São Nicolau support a much lower number of nests, with an annual mean of around 500 nests on each of these islands (Cozens 2009, Cozens *et al.* 2009, Lino *et al*. 2010, A. Marco unpubl. data). On the remaining islands in the archipelago, nesting density is much lower and is estimated to be less than 150 nests annually per island (Loureiro 2008, A. Marco *et al.* unpubl. data).

The Cape Verde loggerhead turtle constitutes a regional conservation unit (Wallace *et al.* 2011), genetically distinct from other loggerhead populations in the Atlantic and Mediterranean (Monzón Argüello *et al.* 2010a). This genetic distinctiveness indicates considerable

reproductive isolation, with little gene flow from other populations (Monzón Argüello *et al.* 2010a). Phylogeographic analysis shows that the loggerhead turtle population of Cape Verde is more closely related to the populations of northeastern Florida, North Carolina and Brazil than to those of West Africa (Monzón Argüello *et al.* 2010a).

Although many turtles exhibit high nesting site fidelity (they usually nest at the same beach during one or several seasons), some turtles have been observed making two consecutive nests at different islands that were more than 70 km from each other and separated by waters over 1,000 m deep, within a single nesting season (Abella *et al*. 2010). These observations are consistent with the genetic results of the population structure analysis in the archipelago, in which no genetic differences were observed between reproductive females from different islands (Monzón Argüello *et al.* 2010a). There is a great plasticity in nesting fidelity and a significant flow of nesting females between islands. Therefore, the whole Capeverdean archipelago can be considered as a single management and conservation unit.

Through the analysis of molecular microsatellite markers, it has been possible to evaluate the levels of multiple paternity in this loggerhead population. In research conducted by Sanz *et al*. (2008a, b), 66.7% of the analyzed nests had been fertilized by more than one male. The average number of males found per nest was 2.2, although within one nest, a single male often fertilized more than half of the eggs. The high level of paternity, together with the fact that males of nests from different females were also different, suggests that the adult male population is abundant, despite being persecuted by poachers, as some of their body parts are believed to be aphrodisiac. Furthermore, the loggerhead nesting aggregation of Boavista has the highest rate of multiple paternity registered to date for this species.

Fig. 1. Exceptional diurnal nesting of a loggerhead turtle *Caretta caretta*, Praia do Carreto, Boavista, 3 September 2007 (Adolfo Marco).

Fig. 2. Egg laying by a loggerhead turtle *Caretta caretta* in a vegetated dune in southeastern Boavista, 29 August 2006 (Adolfo Marco).

REPRODUCTIVE PATTERN AND NATURAL THREATS

While in continental rookeries nesting commonly takes place along thousands of kilometres of coast (Florida, Caribbean, Gulf of Mexico, Brazil, eastern Mediterranean), the main nesting grounds of this insular population are concentrated on *ca.* 40 km of beach. At the *Reserva Natural das Tartarugas*, along the southeastern coast of the island of Boavista, 15 km of beach host around 60% of all nesting females in Cape Verde and possibly contain the highest nesting density of this species in the world, with more than two nests per linear metre of beach in stretches over 800 m long. This makes these nesting beaches extremely vulnerable to any kind of disaster (oil spills, tropical storms, etc.) or artificial impacts (urbanization, linear infrastructures, artificial lighting, mass tourism, etc.).

The reproductive biology of the Cape Verde loggerhead turtle is peculiar because of the small size of nesting females. The annual average curved carapace length of nesting females is around 82 cm (min. = 67; max. = 107.7; SD = 3.97; N = 4334) (Ballell Valls & López Jurado 2004, Varo Cruz *et al.* 2007). This is slightly larger than Mediterranean loggerhead turtle populations from Greece, Turkey and Cyprus, which have the smallest reproductive size found in this species (see Ballell Valls & López Jurado 2004).

In Cape Verde, many adult males and females can be observed mating in waters close to shore from April-May to just before the nesting season that starts in June and ends mid-October. Nesting success (number of nests laid against the total number of tracks on the beach) on the most important nesting beaches varies, but is usually between 26% and 44% (López *et al.* 2003, Díaz Merry & López Jurado 2004, Varo Cruz *et al.* 2007). Nests have an average depth of around 48.4 cm (min. = 34; max. = 67; SD = 6.56; N = 68) (Varo Cruz *et al.* 2007, Martins *et al.* 2008). The percentage of developing embryos at the start of incubation is higher than 83.5%,

ranging from 75 to 100% (SD = 7.39; N = 29) (Abella *et al.* 2006). Clutch size averages 85 eggs (min. = 24; max. = 143; SD = 16.9; N = 109) (Lozano Fernández & López Jurado 2004, Varo Cruz *et al.* 2007) and incubation time averages 58 days, varying from 45 to 74 days (SD = 3.9; N = 432) (Varo Cruz *et al.* 2007), depending on the beach, month and nesting season. Emergence of hatchlings takes place from the end of August until December. The mean emergence success of natural nests on the main nesting beaches of Boavista is extremely variable and relatively low, with mean values varying from 20 to 60% (Del Ordi *et al*. 2003, García Carcel & López Jurado 2004, Varo Cruz *et al.* 2007). Compared to other loggerhead populations around the world, this demographic parameter is relatively low (see García Carcel & López Jurado 2004). The main causes of this low emergence success in natural nests are 1) predation of eggs by the ghost crab *Ocypode cursor* (Da Graça *et al*. 2010), 2) flooding of nests by high tides and 3) the high clay content of some incubation substrates (Marco *et al.* 2008a). The mean rate of nest predation by crabs can be over 50 % on high density nesting beaches (Da Graça *et al.* 2010). There are no native mammalian predators of eggs on the main nesting beaches, although predation by feral cats and dogs occurs. The ghost crab is the main predator of eggs, but there are other secondary predators, such as the brown-necked raven *Corvus ruficollis*, which feeds on nests destroyed by crabs. In addition, colonies of the fungus *Fusarium solani* have been identified in Cape Verde turtle nests, which in some situations can act as pathogens (Abella *et al.* 2008a, Sarmiento Ramírez *et al.* 2010). Once hatchlings hatch and emerge from the nest, ghost crabs and ravens are their main predators and feral cats can sometimes be seen prowling around turtle nests.

Fig. 3. Predation by ghost crabs *Ocypode cursor*, the inundation of nests by high tides and the presence of clay in the incubation substrate are the main natural causes of mortality in sea turtle nests in the Cape Verde Islands (Adolfo Marco).

Incubation temperature varies depending on the year, the time of incubation within the same nesting season and the nesting site, but on the main nesting beaches the annual average temperature of sand at 40 cm depth ranges from 26.5ºC to 30.6ºC (Abella *et al.* 2007, 2008b). On beaches with black sand, incubation temperature can be considerably higher, causing problems to developing embryos. From the average incubation temperature during the period of sex determination (i.e. the second third of incubation), it is estimated that the sex ratio produced at the main nesting beaches is biased towards females, representing *ca.* 65-75% of hatchlings (Abella *et al.* 2007). Delgado *et al*. (2008) obtained very similar results in their histological analysis of dead hatchlings found on the beach. Compared with other Atlantic populations, where it is estimated that the ratio of female hatchlings is around 90% (Marcovaldi *et al.* 1997, Hanson *et al.* 1998, Baptistotte *et al.* 1999), these data indicate that despite the high production of females a considerable number of males is produced.

MARINE LIFE

The feeding grounds of adult female loggerheads are located in waters off the Atlantic coast of Africa. From satellite tracking studies of adult turtles, we know that females, and possibly also males (Cejudo *et al.* 2008), appear close to the coast between Mauritania and Sierra Leone during the non-reproductive period between nesting seasons (Hawkes *et al.* 2006). In addition, a dichotomy has been observed in the migratory behaviour of females: the larger turtles migrate southward to benthic feeding grounds along the coast of Sierra Leone, whereas small-sized females migrate to oceanic waters off Mauritania, The Gambia and Senegal (Hawkes *et al.* 2006).

Loggerhead turtles usually carry many epibionts. Which species of epibiont attaches to a sea turtle depends on the migration route it follows. The most common genus of epizoic flora found on loggerheads in Cape Verde is *Polysiphonia* and the most common fauna are two species of Cirripedia, i.e. *Lepas anatifera* and *Conchoderma virgatum*, a species of barnacle *Chelonibia testudinaria*, many Amphipoda (Caprellidae, Gammaridae), a number of isopods and also Tanaidacea (Loza & López Jurado 2008). Another epizoic group that has been found on loggerheads in Cape Verde are the Hydroidea, represented by *Obelia geniculata* (Loza & López Jurado 2008).

Juvenile loggerheads originating from Cape Verde have been genetically identified at feeding grounds off the Canary Islands, Madeira, the Azores and the western Mediterranean (Monzón Argüello *et al.* 2009). They share these feeding grounds with juveniles of the same species from other Atlantic and Mediterranean populations. Although the northward dispersal of Capeverdean juveniles is clear, Monzón Argüello *et al*. (2010a) concluded that *ca.* 43% of Capeverdean juveniles are not found in the studied feeding areas. These juveniles could be feeding at unknown and/or non-studied foraging grounds, but could also represent juveniles eliminated from the metapopulation (e.g. mortality in the early stages or in fisheries). Recently, a juvenile specimen found in an area near the coast of Ceará, Brazil, carried a haplotype that to date has only been identified in Cape Verde (Cardinot Reis *et al.* 2009). This indicates the need for genetic studies at other feeding grounds in the western Atlantic and the possible existence of feeding grounds of juvenile loggerheads yet to be discovered. It is possible that a significant number of juveniles disperse to American waters or southward to the Gulf of Guinea (Monzón Argüello *et al*. 2010a).

Fig. 4. Carcass of a slaughtered loggerhead turtle *Caretta caretta*, Praia da Boa Esperança, Boavista, 15 September 2009 (Hector Garrido). The slaughter of turtles for meat consumption and the destruction of nesting habitats due to the development of the tourism industry are the main human caused threats to sea turtles in the Cape Verde Islands.

NEW THREATS AND CONSERVATION STATUS

The conservation status of the Cape Verde loggerhead turtle population is of great concern. In Cape Verde, the consumption of sea turtle meat is a long-standing tradition, as is the consumption of eggs on some islands, the hunting of males for aphrodisiacs and the use of turtle shells in handicrafts (Cabrera *et al*. 2000, Loureiro & Torrão 2008). In 1987, the Cape Verde government first regulated the hunting of sea turtles during the nesting season (Decree-Law No. 97/87). In 2002, hunting was banned during the whole year (Decree-Law No. 7/2002), but only from 2005 onwards, possession, hunting, consumption and exploitation of sea turtles and their eggs became explicitly prohibited by law (Article No. 40 of Decree-Law No. 53/2005). These legal measures have probably decreased the hunting pressure, but have not stopped the long decline of sea turtles in Cape Verde (Cabrera *et al.* 2000, Loureiro & Torrão 2008). At present, a fast developing tourist industry is threatening turtle nesting habitats on several islands (see Taylor & Cozens 2010). The widespread use of quads and 4-wheel drive vehicles has a devastating effect on loggerhead nesting areas, while the arrival of many low-waged workers from continental Africa, who work in the construction of new hotels, has increased hunting pressure on sea turtles in recent years. This critical situation, as manifested by the uncontrolled illegal killing of females on the beach (Marco *et al.* 2008b), has brought about an increased commitment and involvement by regional, national and international organizations for the conservation of sea turtles in the archipelago. It seems that the protection and awareness efforts of recent years are starting to bear some fruit, but it remains necessary to increase protection and cooperation initiatives for sustainable development in order to safeguard the survival of this emblematic Atlantic population. Recently, the Capeverdean Sea Turtle Network (TAOLA) was created to coordinate efforts and improve communication between various organisations and governmental bodies.

On 13 December 2010, the Government of Cape Verde approved the National Plan for the Conservation of Marine Turtles (Resolution nº 72/2010). The general objective is to improve and ensure the conservation and sustainable use of marine turtles for ecotourism in Cape Verde in an integrated way. This should provide competent institutions with the means to coordinate the implementation of activities of the conservation plan, promote enforcement of laws for the conservation of marine turtles, contribute to a better understanding of the species of marine turtles in Cape Verde and promote a favourable attitude toward conservation and sustainable use of marine turtles with touristic enterprises and the general population. This National Plan is an important guiding tool in the conservation of these endangered marine species and will not only contribute to the conservation of these species in Cape Verde, but also on an international level.

Cape Verde supports the only major nesting area for loggerhead turtles along the entire eastern Atlantic coast. The high philopatry of female sea turtles and extremely slow dispersion of sea turtle nesting grounds implies that the Cape Verde nesting grounds are going to be essential for the reproduction of loggerhead turtles during the next decades and beyond. We are confident that with the efforts of all Capeverdean institutions (Roder 2009), as exemplified in the recently approved National Plan for the Conservation of Marine Turtles, the increasing awareness and education of the local communities (Espirito Santo *et al.* 2008), the economic and social development associated with an emerging ecotourism, the increase in international cooperation and a combination of many supportive contributions, the necessary recovery and conservation of sea turtles in Cape Verde will become a reality.

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