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Body size and stability in the spatio-temporal distribution pattern of sea turtles along the coasts of Togo: implications for conservation and ecotourism

(Testudines: Cryptodira: Cheloniidae, Dermochelyidae)

Körpergröße und Konstanz im räumlich-zeitlichen Verteilungsmuster der Meeresschildkröten entlang Togos Küsten: Folgerungen für Schutz und Ökotourismus

(Testudines: Cryptodira: Cheloniidae, Dermochelyidae)

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KURZFASSUNG

Die Körpergröße der Meeresschildkröten und ihre auf die jeweilige Art bezogene Konstanz im Aufsuchen bestimmter Nistplätze entlang der Küste von Togo (Westafrika) wurden untersucht. Darüber hinaus erfolgte eine Beurteilung der Schutzbedürftigkeit dieser Schildkröten einschließlich von Überlegungen zum nachhaltigen Management der lokalen Populationen. Die Feldstudie wurde mit Hilfe sogenannter "eco-guards" durchgeführt und bezog sich auf fünf Strandabschnitte. Insgesamt umfaßt die Studie Nachweise von 2025 Schildkröten während zweier Jahre (Oktober 2012 bis August 2014). Fünf Arten wurden beobachtet; zwei davon waren in beiden Jahren zahlenmäßig vorherrschend, *Lepidochelys olivacea* (ESCHSCHOLTZ, 1829) und *Chelonia mydas* (LINNAEUS, 1758), eine, *Dermochelys coriacea* (VANDELLI, 1761), wurde in beiden Jahren weniger häufig aber regelmäßig registriert und zwei, *Caretta caretta* (LINNAEUS, 1758) und *Eretmochelys imbricata* (LINNAEUS, 1766), nur sporadisch festgestellt. Die gewonnenen Daten über die Körpergröße stehen für alle vermessenen Arten außer *D. coriacea* im Einklang mit den Literaturangaben. Bei dieser Art waren die reproduzierenden Weibchen aus Togo kleiner als artgleiche Tiere anderer Fundorte.

Innerhalb jeder Art war die Konstanz im Aufsuchen bestimmter Nistplätze insofern sehr ausgeprägt, als über zwei Jahre hinweg offensichtlich jeweils Präferenzen für dieselben Strandabschnitte bestanden, selbst solche innerhalb der Stadtgrenzen von Lomé. Dieses Muster läßt die Entwicklung und Implementierung von meeresschildkrötenzentrierten Ökotourismus-Programmen an der togolesischen Küste machbar erscheinen, zumal der Tourismus gegenwärtig bereits eine Haupteinnahmequelle für das Land ist und es außerhalb von Lomé auch schon eine Einrichtung gibt, die auf Meeresschildkröten-Ökotourismus ausgerichtet ist.

ABSTRACT

Body size of sea turtles and their species-specific fidelity towards certain nesting beaches along the coast of Togo, West Africa, were studied. Furthermore, these turtles' need for conservation was assessed, including considerations for a sustainable management of the local populations. The field study was carried out with the help of eco-guards, and was concentrated at five beach sections. The total sample consisted of 2,025 individuals across two years (October 2012 until August 2014). Five turtle species were observed. Two were dominant in both years, *Lepidochelys olivacea* (ESCHSCHOLTZ, 1829) and *Chelonia mydas* (LINNAEUS, 1758), one, *Dermochelys coriacea* (VANDELLI, 1761), being less common but regularly seen in both years and two being just sporadically observed, *Caretta caretta* (LINNAEUS, 1758) and *Eretmochelys imbricata* (LINNAEUS, 1766). Data on body size obtained during this study are consistent with available information from the literature, except for *D. coriacea*. The Togolese reproductive females of this species appear smaller than conspecifics from elsewhere.

Within species, the observed numerical stability in the use of certain nesting beaches was high; i. e., in two consecutive years there was an apparent preference of the same beach sections, even inside urban Lomé. This pattern suggests that it may be very feasible to develop and implement a sea turtle-based ecotourism program for the Togolese coast, also because tourism is currently a main income source for Togo and there is already a tourist location outside Lomé for sea turtle enthusiasts.

KEY WORDS

Reptilia: Testudines: Cryptodira: Dermochelyidae; *Dermochelys coriacea*; Cheloniidae: *Caretta caretta*, *Chelonia mydas*, *Eretmochelys imbricata*, *Lepidochelys olivacea*, marine turtles; ecology; behavior, monitoring, nesting beaches choice stability across years, morphology, body size, conservation, ecotourism, Togo

INTRODUCTION

Although (i) sea turtles are traditionally among the most studied species in terms of their natural history attributes that have relevance for planning and implementing conservation programmes, and (ii) wide coastal regions of Africa have priority importance for global conservation strategies on sea turtles (e.g., Fretey 2001), there are very few long-term studies on the ecology of African sea turtle populations (e.g., Metcalfe et al. 2015). In West Africa, despite preliminary and scattered data available for a variety of countries, including Cameroon, Gabon, Congo, Sao Tome, and Nigeria (Deem et al. 2007; Formia et al. 2007; Fretey et al. 2007; Witt et al. 2008; Akani & Luiselli 2009; Ferreira & Martins 2013; Metcalfe et al. 2015), the implementation of global conservation strategies is certainly curtailed not only by logistic and funding problems, but also lack of ecological knowledge. An exception of this pattern is represented by coastal Togo, where several species of sea turtle are found and long-term ecological research is done continuously by scientists with support of a volunteer staff (e.g., Segniagbeto 2004; Segniagbeto et al. 2013, 2014, 2016, in press). In particular, in a recent paper (Segniagbeto et al. 2016), the spatial and temporal patterns of occurrence (phenology) of some sea turtle species were analyzed, with emphasis on whether these turtles do exhibit site-specific preferences for egg-laying and other routine activities along the Togolese coast.

In the present study, the authors added a novel set of sea turtle monitoring data to the information available in Segniagbeto et al. (2016) to verify:

(i) whether or not the sea turtle populations of Togo are comparable to other conspecific populations from elsewhere in terms of body size (i.e., age). This is to assess whether the Togolese populations are representative of the general condition of their conspecifics for conservation planning;

(ii) whether or not there is annual and species-specific stability in the number of sea turtle nesting sites;

(iii) the conservation status of the various sea turtle species in Togo, and

(iv) potential sea turtle conservation actions that can be taken at the country level.

MATERIALS AND METHODS

This paper is based on field data collected from October 2012 to August 2014; data collected from October 2012 to September 2013 were already published by Segniagbeto et al. (2016). All information presented here was gathered by the authors in cooperation with the NGO AGBOZEGUE (Association togolaise pour la conservation de la nature / Togolese Society for the Conservation of Nature). This study was conducted with the help of specifically instructed eco-guards, who monitored the Togolese coast from the townships of Kodjoviakopé to Agbodrafo (Djeke).

The whole monitored coast (42 km in total) was subdivided into five sections (Fig. 1). For definition and description of the sections see Segniagbeto et al. (2016).

On each of the five sections, two eco-guards, specifically educated for this study, patrolled the whole transect on a daily basis and collected the data. Eco-guards monitored the beaches for ovipositing or stranded turtles, and also recorded the specimens brought by fishermen. Eco-guard patrolling activity occurred both by day (hrs 11:00 am to 04:00 pm) and night (between hrs 4:00 and 6:00 am), when fishermen come back from fishing. Each turtle was identified to species and sex, and for most specimens both the carapace length and width was measured with a tape (to the nearest cm; see Bolten 1999).

The field effort (about 15 person hours per month and km of beach) was identical across months, between years, and among

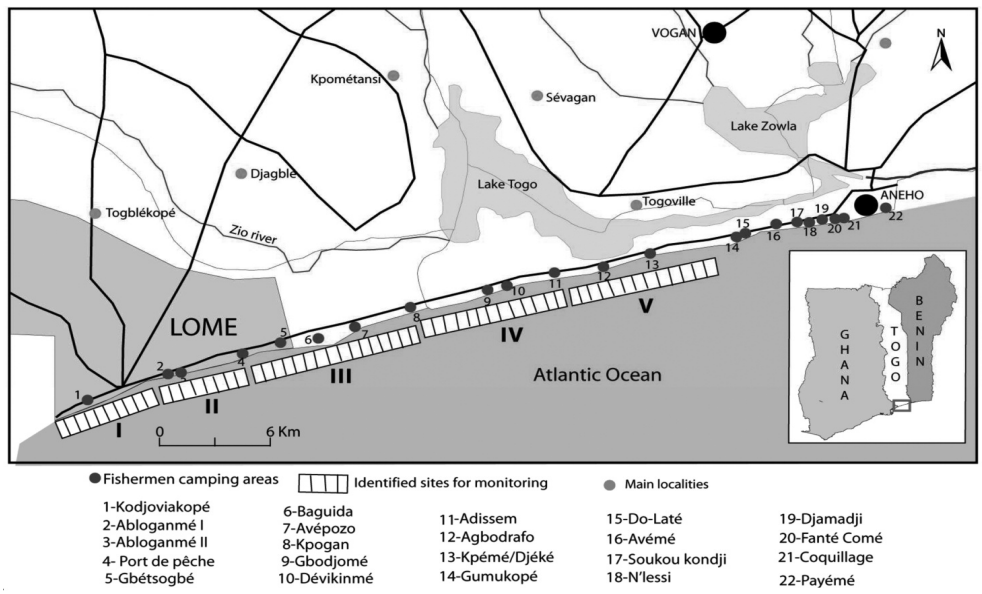

Fig. 1: The position of five sections (I to V) along the Togolese coast defined for the present sea turtle study.
Abb. 1: Die Lage der fünf Abschnitte (I – V), die zur vorliegenden Untersuchung der Meeresschildkrötenvorkommen an der Küste von Togo festgelegt wurden.

the five sections (two hours per day and section; an hour between 11:00 and 04:00 and an hour between 04:00 and 06:00).

Intersexual differences in mean carapace length and in mean carapace width were tested by Student t-test. Correlation between carapace length and width was tested by Pearson's correlation coefficient, and the intersexual statistical difference in the overall regression of carapace width (CW) against carapace length (CL) was assessed by one-way Analysis of Covariance (heterogeneity of slopes test).

All tests were two-tailed, with alpha set at 5 %. Statistical analyses were performed by PAST software (version 3.0). Means are followed by ± 1 Standard Deviation.

RESULTS

Sample sizes and recorded species

The overall sample consisted of 2,025 individuals across two years, with 743 of them being recorded between October 2012 and September 2013, and 1,282 from October 2013 to August 2014. In the second year of monitoring (2013), not only the number of individuals increased considerably but also the number of observed species, i.e., from three in the first to five in the second year (Fig. 2). Among the five observed species, two were dominant in both years, *Lepidochelys olivacea* (ESCHSCHOLTZ, 1829) and *Chelonia mydas* (LINNAEUS, 1758), one was less common but regularly seen in both years, *Dermochelys coriacea* (VANDELLI, 1761), and two were exceedingly rare and observed in just the second year of monitoring, *Caretta caretta* (LINNAEUS, 1758) with just three records, and *Eretmochelys imbricata* (LINNAEUS, 1766) with a single record (Fig. 2). Concerning *E. imbricata*, the single record refers to a juvenile found dead on the

Lomé beach in front of the Wharf Monument on September 17, 2013.

Body size structure

In *L. olivacea*, CL and CW were positively correlated in either sex (females: $r = 0.915$, $P < 0.0001$; males: $r = 0.921$, $P < 0.0001$; Fig. 3). The sexes were similar in terms of their mean CL ($t = 1.04$, $df = 298$, $P = 0.226$) and CW ($t = 0.343$, $df = 298$, $P = 0.710$). A heterogeneity of slopes test did not reveal any intersexual difference in terms of the general regression between CL and CW (ANCOVA – $F_{1,297} = 0.166$, $P > 0.685$).

The above patterns were also found for *C. mydas*: CL and CW were positively correlated in either sex (females: $r = 0.968$, $P < 0.0001$; males: $r = 0.970$, $P < 0.0001$; Fig. 4) and both sexes attained similar mean CL ($t = 0.69$, $df = 377$, $P = 0.493$) and CW ($t = 0.767$, $df = 377$, $P = 0.444$). A heterogeneity of slopes test showed no intersexual differences for the general regression between CL and CW (ANCOVA – $F_{1,376} = 0.01$, $P > 0.970$).

The size of three *C. caretta* specimens recorded was: CL = 66-71 cm, and CW = 63-69 cm. The single *E. imbricata* was a female of 46 cm CL and 40 cm CW; its sex was determined by autopsy. All measured individuals of *D. coriacea* were females, their size ranging 124-150 cm CL ($\bar{x} = 136.4 \pm 7.7$, N = 12) and 90-119 cm CL ($\bar{x} = 103.2 \pm 5.5$, N = 12). As expected, carapace length and width were significantly positively correlated ($r = 0.693$, $P < 0.01$; Fig. 5).

Within species stability of nesting beach choice across years

Patterns of the turtle species' preference for certain beach sections in two consecutive study periods (for each species expressed as percentage of specimens recorded in each beach section and study period) are shown in Fig. 6. For all three species recorded in both years, there was a substantial consistency in the preference for certain beach sections (Fig. 6), despite the small size of each section if compared to a sea turtle typical home range.

Indeed, the numbers of specimens per section counted in the two study periods (2012-13 and 2013-14) were significantly, positively correlated in both *C. mydas* ($r = 0.993$, $N = 5$, $P < 0.001$) and *D. coriacea* ($r = 0.89$, $N = 5$, $P < 0.05$). In *E. olivacea*, the pattern was the same, but the correlation fell just short of statistical significance ($r = 0.800$, $N = 5$, $P = 0.063$).

DISCUSSION

Status of the sea turtle species in Togo

Lepidochelys olivacea.– This species is clearly the most common sea turtle species along the coast of Togo, as shown not only by the high number of individuals recorded during our monitoring activities (see above), but also by the number of shells presented to us by interviewed people from coastal villages (Segniagbeto 2004; Segniagbeto et al. 2014a). Interestingly, this species was not mentioned to occur in Togo by earlier authorities, as it was first cited by Fretey (2001) on the basis of four carapaces originating from Aneho and offered for sale in the port of Abidjan (Ivory Coast), with Formia (in Fretey 2001) confirming its nesting in some Togolese beaches.

Since many adult males were captured by fishermen in the open water or found dead ashore during the present study (61 individuals in the first and 46 in the second year), it is likely that the Togolese waters constitute a mating area for this species. Indeed, several interviewed fishermen confirmed this hypothesis by witnessing that several mating pairs of this species were regularly observed nearby the Togolese coast. Such an abundance of males is quite exceptional in the Gulf of Guinea, and was observed only at Sao Tomé and in the Democratic Republic of Congo (Maxwell et al. 2011; Metcalfe et al., 2015).

IUCN (2015) assessed this species as Vulnerable. Along the Togolese coast, this species may be under threat due to (i) interactions with the port activities in the Lomé

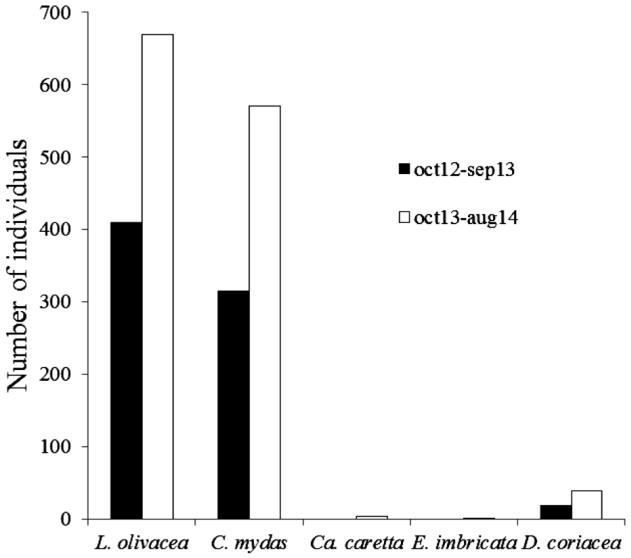

Fig. 2: Number of specimens out of five species of sea turtles recorded along the coast of Togo during two study periods (October 2012 until September 2013 - black bars; October 2013 until August 2014 - white bars).

Abb. 2: Individuenzahlen von fünf Meeresschildkrötenarten, wie sie entlang der Küste von Togo während zweier Untersuchungsperioden (Oktober 2012 bis September 2013 - schwarze Balken; Oktober 2013 bis August 2014 - weiße Balken) festgestellt wurden.

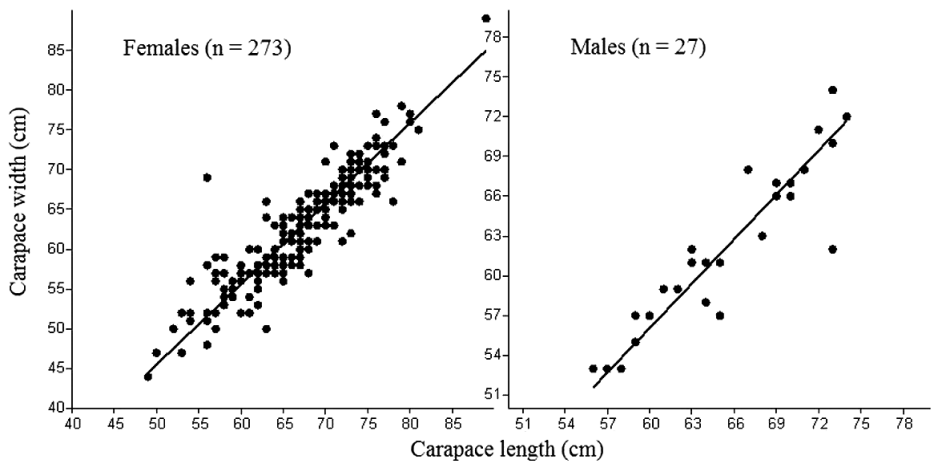

Fig. 3: Relationship between carapace length and width in 300 *Lepidochelys olivacea* (ESCHSCHOLTZ, 1829) from Togo. For the statistical tests, see text.
The males were either found dead ashore or captured by fishermen off the coast.

Abb. 3: Die Beziehung zwischen Karapaxlänge und -breite bei 300 *Lepidochelys olivacea* (ESCHSCHOLTZ, 1829) von Togo. Zur Statistik siehe Ergebnisse.
Die Männchen wurden teils tot auf dem Strand gefunden, teils von Fischern gefangen.

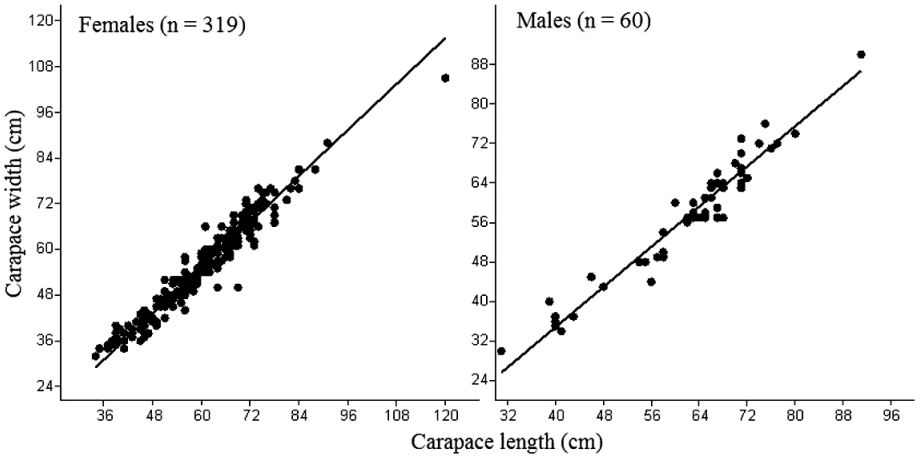

Fig. 4: Relationship between carapace length and width in 379 *Chelonia mydas* (Linnaeus, 1758) from Togo. For the statistical tests, see text.
The males were either found dead ashore or captured by fishermen off the coast.

Abb. 4: Die Beziehung zwischen Karapaxlänge und -breite bei 379 *Chelonia mydas* (Linnaeus, 1758) von Togo. Zur Statistik siehe Ergebnisse.
Die Männchen wurden teils tot auf dem Strand gefunden, teils von Fischern gefangen.

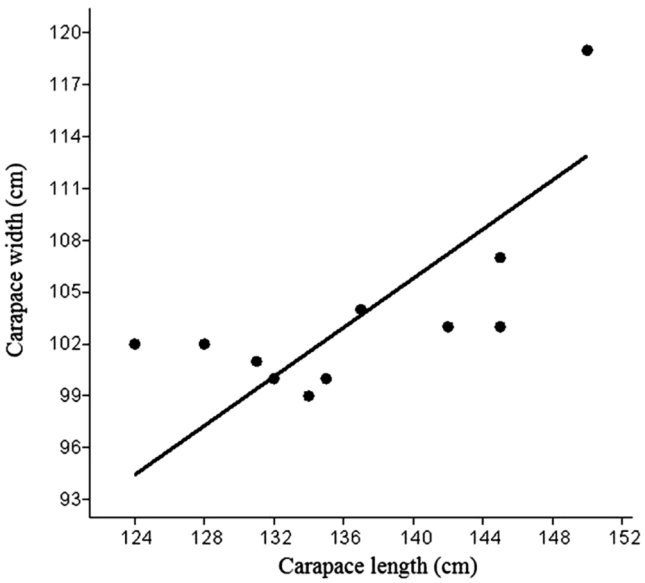

Fig. 5: Relationship between carapace length and width in 11 female *Dermochelys coriacea* (Vandelli, 1761) from Togo. For the statistical tests, see text.

Abb. 5: Die Beziehung zwischen Karapaxlänge und -breite bei 11 Weibchen von *Dermochelys coriacea* (Vandelli, 1761) von Togo. Zur Statistik siehe Ergebnisse.

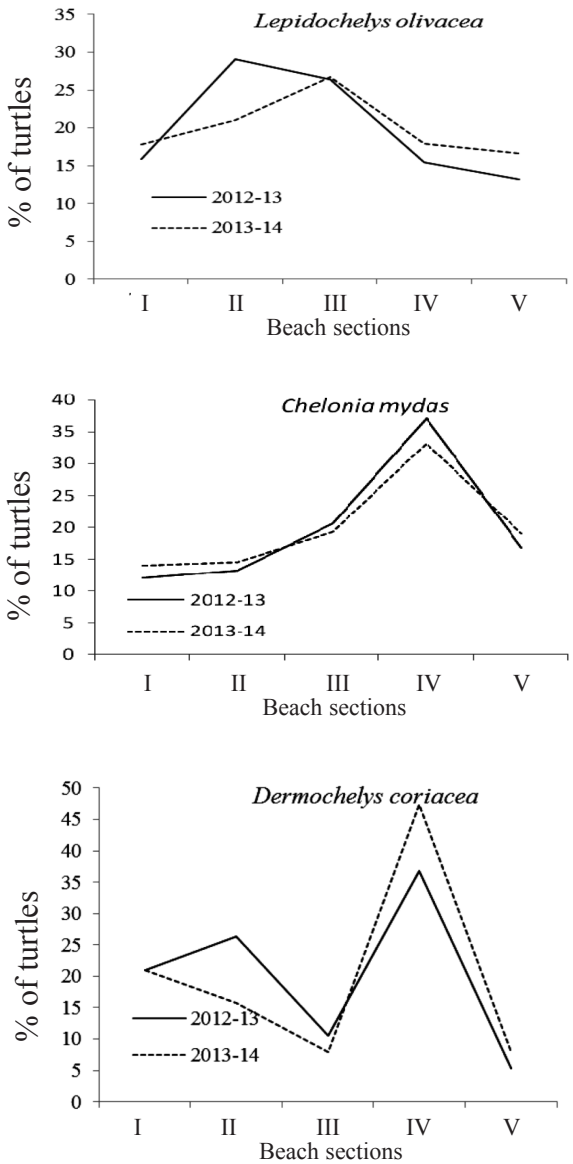

Fig. 6: The numerical distribution of three sea turtle species (expressed as percent of individuals counted at beach sections I to V) along the coast of Togo in two consecutive observation periods. Sample sizes are given for the periods 2012-2013 and 2013-2014, respectively. *Lepidochelys olivacea* (ESCHSCHOLTZ, 1829) - 409 and 670; *Chelonia mydas* (LINNAEUS, 1758) - 315 and 570; *Dermochelys coriacea* (VANDELLI, 1761) - 19 and 38.

Abb. 6: Die zahlenmäßige Verteilung (in Prozent der Individuen, welche an den Strandabschnitten I bis V gezählt wurden) dreier Meeresschildkrötenarten entlang der Küsten Togos in zwei aufeinanderfolgenden Beobachtungsperioden. Die Stückzahlen sind jeweils für die Beobachtungsperioden 2012-2013 und 2013-2014 angegeben. *Lepidochelys olivacea* (ESCHSCHOLTZ, 1829) - 409 und 670; *Chelonia mydas* (LINNAEUS, 1758) - 315 und 570; *Dermochelys coriacea* (VANDELLI, 1761) - 19 und 38.

area, (ii) industrial and artisanal fishing, (iii) development of the nesting beaches for touristic and economic reasons (hotels, bars, bungalows), and (iv) light pollution at night in several important nesting beaches. The high potential for decline of *L. olivacea* in Togolese waters, witnessed by numerous dead individuals found, calls for a careful conservation program.

Chelonia mydas.– This is the second most common species of sea turtle in Togo. It was recorded to occur in the country by Stuart et al. (1990), Fretey (2001), Segniagbeto (2004), Bowessidjaou et al. (2006) and Segniagbeto et al. (2014a). The present data confirms the observation by Segniagbeto et al. (2013, 2014a) that turtles of both sexes and all age classes are represented along the Togolese coast (where out of 570 individuals recorded in 2013-2014, adults accounted for 57 %, sub-adults for 35 % and juveniles for 8 %) as well as the hypothesis by Segniagbeto et al. (2016) that Togolese waters maybe an important regional feeding ground for this species.

Overall, the Togolese population of *C. mydas* seems to be relatively abundant, although the development of port infrastructures and the pressure by industrial fishing may represent potential threat to this species. These turtles do not nest in Togolese beaches whereas, they probably do this on Bioko Island (Fretey 2001) and migrate from Bioko to Togo to forage. Anthropogenic perturbation due to maritime industries may thus affect the populations of this turtle not only in Togo but also in the whole of the Gulf of Bénin (Ghana, Togo, Bénin and Nigeria).

Caretta caretta.– The presence of this species in Togo was unknown before very recently (Segniagbeto et al. in press). Since only three specimens were recorded during the present surveys, this species must be extremely rare at the local scale. The specimens were captured in three distinct sites of Lomé, i.e., in front of the Hôtel Santa Maria (July 4, 2014), at Tangokopé (July 17, 2014), and outside the port of Kpeme (August 10, 2014). This species is rarely recorded from the Gulf of Bénin, although some individuals were observed at São Tomé Island (Graff 1995a, 1995b; Dontaine & Neves 1998, 1999), where, however *Caretta* does not nest (there are recent records of nesting females in Ghana; Phil pers. comm.). Future studies should assess whether the Togolese populations of *C. caretta* may be important for the global conservation strategies of this species.

Eretmochelys imbricata.– This is another very rare species in the area, as it was observed just once in two years of careful monitoring. In addition, a total of eight carapaces were recorded by Segniagbeto (2004) in various coastal villages, with four of them coming from the village of Gbétsogbé. Surprisingly, given the current rarity of this species, *E. imbricata* was recorded for the country already by Boulenger (1905), and later by Loveridge & Williams (1957), Villiers (1958), Stuart & Adams (1989), and Stuart et al. (1990). Formia (in Fretey 2001) and Bowessidjaou et al. (2006) noticed that Togolese waters are inhabited by juveniles of this species. Nonetheless, 50 % (N = 8) of the specimens recorded by Segniagbeto (2004) were adults. Segniagbeto (2004) and Segniagbeto et al. (2013, 2014a) concluded that the species does not reproduce in Togo, as also showed by the present surveys. Overall, this species seems to be exceedingly rare in Togo, and urgent conservation measures should be taken by competent authorities. The absence of true coral reefs and the typical solitary nesting behavior of this species probably explain the knowledge gaps about the actual status of *E. imbricata* in West Africa (Fretey et al. 2000).

In the Gulf of Guinea, the species oviposits mainly on islands (Bioko, Principe, São Tomé, Ilhéu das Rolas), and more sporadically in continental beaches, primarily in Gabon. Individuals sometimes observed in Togo are most probably erratic turtles coming from island populations.

Dermochelys coriacea.– The occurrence of *D. coriacea* in Togo is long known to science (Matschie 1893; Tornier 1901), with Sebbe (Zébé currently Aného) being the first locality of its presence ascertained. However, despite several sources confirming the presence of this species over the years (Loveridge & Williams 1957; Brongersma 1981-1982; Stuart & Adams 1989; Fretey 2001; Bowessidjaou et al. 2006; Fretey et al. 2007), virtually nothing

was known on the population status of this species prior to the studies by SEGNIAGBETO (2004) and SEGNIAGBETO et al. (2013, 2016). These latter studies reported the occurrence of 27 nests between September 2002 and February 2003 in Togo and, along with the present analysis, revealed that all the *D. coriacea* individuals observed in Togo were adult females.

The population size of *D. coriacea* is relatively important in Togo, given that the field sightings of this species are scattered as for the Gulf of Guinea (FRETEY 2001). Nonetheless, this species may be under the threats enumerated under *L. olivacea.*

Body size comparisons

Data on body size and proportions obtained during this study for *C. mydas* and *E. olivacea* are consistent with the few literature data of specimens from along the Togolese coast and elsewhere. For instance, BOWESSIDJAOU et al. (2006) observed a linear relationship between curved carapace length (CCL) and curved carapace width (CCW) in *C. mydas* (Pearson's $r = 0.992$). This was similar to the authors' results for *C. mydas* ($r = 0.968$ for females; $r = 0.970$ for males) and *L. olivacea* ($r = 0.915$ for females; $r = 0.921$ for males). Similar findings were obtained for *C. mydas* by BJORNDAL & BOLTEN (1989).

Togolese females of *D. coriacea* were on average smaller than females observed in other countries, e. g., in Gabon (VERHAGE & MOUNDJIM 2005). If this difference is not accidental (N = 11 only; Fig. 5), the reasons remain unexplained.

Constancy of spatial frequency distribution and conservation implications

Within each of the three abundant turtle species, the authors observed that their spatial frequency distribution in Togolese beaches was similar among years (although not statistically significant in *E. olivacea*). It is well known that female sea turtles show high site fidelity to their nesting beaches (e.g., BOWEN et al. 1992; HATASE et al. 2004). Beyond this, the present study revealed species-specific preferences of certain sectors of certain beaches in conspicuous annual constancy, even inside urban Lomé. This aspect speaks in favor of the creation of a marine protected area along the Togolese coast. In the framework of the project on the creation of the transboundary biosphere reserve in the Mono Delta funded by the International Climate Initiative (IKI), one major step to be taken is the creation of a marine protected area between Togo and Benin. Three of five sections (sites III, IV and V) surveyed in the current study are included in the area considered as the transboundary marine protected area. In this area, in addition to sea turtle species and their nests, many emblematic marine animals such as Antarctic minke whale (*Balaenoptera bonaerensis*), humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), short-finned pilot whale (*Globicephala macrorhynchus*), pantropical spotted dolphin (*Stenella attenuata*), common bottlenose dolphin (*Tursiops truncatus*), killer whale (*Orcinus orca*), and Atlantic humpback dolphins (*Sousa teuszii*) were recorded (ZWART & WEIR 2014; SEGNIAGBETO et al. 2014b; VAN WAEREBEEK et al. 2015).

On the basis of the biological potential of the Togolese coast, it is realistic to develop and implement ecotourism programs, because (i) tourism is currently one of the main income sources of foreign money for Togo (ISICA 2012), and (ii) a small touristic resort for sea turtle enthusiasts, with a restaurant and a museum is already available and showed good commercial success. For instance, in the village of Agbodrafo, a center (Village des Tortues) where tourists are informed about sea turtles and where they can eat in front of the sea, is already running under the support of AGBOZEGUE NGO. In addition, (i) the social and political situation in Togo is very calm (Lomé being probably the safest of the West African big cities), (ii) Lomé is easily reached by airlines via Paris, and (iii) there is a growing attention for environmental issues by public authorities in the country. Therefore, the authors are convinced that promoting an ecotourism program with conservation implications is a reasonable opportunity to enhance the management of sea turtles in the country and to provide an effective source of economic development for the people.

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