**Universidade Federal de Ouro Preto**
**Programa de Pós-Graduação em Ecologia de Biomas Tropicais**

# GAPS IN MARINE TURTLE RESEARCH: A 30-YEAR REVIEW

Dissertação apresentada ao Programa de Pós-Graduação em Ecologia de Biomas Tropicais do Instituto de Ciências Exatas e Biológicas da Universidade Federal de Ouro Preto como requisito parcial para obtenção do Título de Mestre em Ecologia.

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# "Gaps in marine turtle research: a 30-years review".

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**“Todas as vitórias ocultam uma abdicação”.**

**Simone de Beauvoir**

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**Lacunas no estudo de tartarugas marinhas: uma revisão de 30 anos**

**Resumo:** Tartarugas marinhas são um grupo carismático de répteis que são distribuídas globalmente, habitam todos os oceanos, ocupam nichos ecológicos únicos e exibem variações intraespecíficas em tamanho populacional, reprodução e morfologia. Todas as sete espécies estão presentes na Lista Vermelha da IUCN, em diferentes níveis de risco. Publicações recentes mostraram que as espécies não estão sendo estudadas em parâmetros iguais, por isso, o presente estudo realizou uma revisão bibliométrica que utilizou a plataforma internacional *The Web of Science*© para realizar uma análise de lacunas (Gap Analysis) com as publicações sobre tartatugas marinhas nos últimos 30 anos; classificando e analisando as mesmas de acordo com categorias selecionadas. Nossos resultados mostraram que o número de publicações cresceu significativamente entre as décadas, mas as espécies não estão sendo estudadas na mesma proporção. Essa grande diferença nos levou a focar nossas análises nas três espécies menos estudadas e as lacunas no conhecimento das mesmas, apontando as áreas de deficiência em cada uma. Nós discutimos porque as publicações estão extremamente concentradas em países desenvolvidos (principalmente Estados Unidos da América), e as possíveis soluções para ajudar os países em desenvolvimento a aumentar sua significância no estudo de tartarugas marinhas, levando em conta que esses países abrigam a maioria dos sítios de reprodução.

**Palavras-chave:** análise bibliométrica, conservação, tartaruga marinha, Testudines.

**Gaps in marine turtle research: a 30-year review**

**Abstract:** Sea turtles are a group of marine reptiles that are globally distributed, occupy unique ecological niches, and exhibit intra-specific variations in population sizes, reproduction and morphology. All seven species are present at different levels of risk at IUCN Red List. The present study was a bibliometric review that used *The Web of Science*© platform to do a Gap Analysis with marine turtle publications of the last 30 years. The publications were classified and analyzed according to several categories, with the objective to understand the trends and gaps in marine turtle research. The number of publications grew significantly through decades, but the species are not being studied at the same proportion. This difference leaded us to focus our analysis on the three less studied species and its lack of knowledge, showing promising areas of study. We discussed why the publications are highly concentrated in developed countries, and the possible solutions to help developing countries to increase their significance in this field, since they host the majority of sea turtles nesting sites. We identified data that is being systematically collected in these nesting sites but is not being well published, which leads the conservation assessments to be based in grey literature and personal communications.

**Additional keywords:** bibliometric analysis, conservation, sea turtle, Testudines.

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## Introduction

Sea turtles (Chelonoidea) are a charismatic group of marine reptiles (Jones *et al.* 2012). Despite consisting of only seven species, they are globally distributed, inhabiting all oceans (except polar regions), occupying unique ecological niches, and exhibiting intra-specific variations in population sizes, as well as in reproduction and morphology (Wallace *et al.* 2010). State of the World's Sea Turtles (SWOT) database (SWOT 2016) maps global distribution of sea turtle nesting sites, and actually shows 3,344 nesting sites and 7,749 nesting records for all species.

The Olive ridley, *Lepidochelys olivacea* (Eschscholtz 1829) has a circumtropical distribution and nest in more than 60 countries (Abreu-Grobois and Plotkin 2008). It is the only species that exhibit two types of reproductive behavior: females can either emerge in mass nesting events called arribadas, or they will emerge solitarily or in a small group without synchrony (Kalb 1999). Leatherbacks, *Dermochelys coriacea* (Vandelli 1761) nest along the tropical Atlantic and Pacific coasts, with an important concentration in Central Africa (Fretey *et al.* 2007). They are the biggest sea turtles, and are known for its deep diving capacity (Eckert *et al.* 1986) and capability of inhabit cold waters (Hodge 1979). The Hawksbill turtle, *Eretmochelys imbricata* (Linnaeus 1766) is a highly specialized turtle, and usually lives associated with coral reefs and other hard-bottom habitats in tropical and subtropical seas (Wood *et al.* 2013). The most restricted species in nesting areas are the Kemp's ridley, *Lepidochelys kempii* (Garman 1880) and the Flatback, *Natator depressus* (Garman 1880). The former nests in the Gulf of Mexico and in a few beaches along the east coast of the USA (Marquez *et al.* 2005), and the latter nests in tropical and subtropical northern Australian coast (Schäuble *et al.* 2006). Green turtles, *Chelonia mydas* (Linnaeus 1758) are the most "common" sea turtles, nesting in more than 80 countries (Hirth 1997), and inhabiting coastal waters of over 140 countries (Groombridge and Luxmoore

1989). The Loggerhead turtle, *Caretta caretta* (Linnaeus 1758) is globally distributed throughout the subtropical and temperate regions of the Mediterranean Sea and Pacific, Indian, and Atlantic Oceans (Wallace *et al*. 2010).

On a global scale, marine turtle species are currently listed as Vulnerable (Olive ridley, *L. olivacea*; Leatherback, *D. coriacea* and Loggerhead, *C. caretta*), Endangered (Green turtle, *C. mydas*), Critically Endangered (Kemp's ridley, *L. kempii* and Hawksbill, *E. imbricata*), and Data Deficient (Flatback, *N. depressus*) on the Red List (IUCN 2016). Two species jumped down on the risk on the last review: Leatherback and Loggerhead went from Critically Endangered and Endangered (respectively) to a Vulnerable status. It is important to consider that Kemp's ridley and Flatback had their last assessments in 1996 (RLS&PS 1996; MTSG 1996) and Green turtles in 2004 (Seminoff 2004), which indicates the need of updating in their classifications. A major hurdle for Red Listing efforts is the lack of reliable studies that have been published and assessments that have had far too much emphasis on grey literature and personal communications (Seminoff and Shanker 2008).

Gap Analysis was initially used to provide a quick overview of the distribution and conservation status of several components of biodiversity (Scott *et al.* 1993). The concepts of preservation and conservation can easily be applied to other subject areas (de Azevedo *et al.* 2007), such as marine turtle research. Recently, Mazaris *et al.* (2014) used a Gap Analysis to overlay maps and understand the relation of protected areas with nesting sites of marine turtles, and identified that the majority of populations nest in developing countries. In another review about plastic ingestion by marine turtles, Nelms *et al.* (2016), showed that the majority of the studies were focused on Loggerhead and Green turtles, in contrast to a small number of reports on the other species. This shows the need for a review in global marine turtle research, to understand

publication trends and highlight knowledge gaps. The aim of the present study was to evaluate trends in the marine turtle research in the last 30 years, pinpointing gaps in the knowledge of this important group of vertebrates.

**Materials and Methods**

The bibliometric review was made in *The Web of Science*© platform because it has truly international coverage, an important characteristic since national databases show biases toward particular types of research (Melfi 2005). The Marine Turtle Newsletter (MTN) provides current information on marine turtle research, but the manuscripts submitted to the MTN are processed using single blind reviewer software (MTN 150, 2016); that is why we did not include these publications on our review.

First, the search was made using the keywords 'sea turtle*' and 'marine turtle*' (*matching singular and plural). Then, all the seven scientific names of the living species of marine turtles were used as keywords. The search was limited to the past three decades (1986 to 2016). Before 1986, less than 20 articles were published per year on the subject of marine turtle research according to the database consulted, and we considered a yearly sample of less than 20 articles to be inadequate to analyze publishing trends.

Our first search found 10,198 references to articles. Combining the nine searches using the toll "OR" (that excludes duplicities), 4,826 references to articles remained. Due to the big amount of references to analyze, we decided to exclude notes, editorials, proceedings papers, meeting abstracts, letters, books and book chapters, analyzing only journal articles and reviews. We then downloaded the 4,204 references to articles to a reference manager software (EndNote X7© - Thomson Reuters) in July of 2016. Then, each abstract was analyzed to confirm that it was

indeed about our subject. Although it would be better to analyze full articles, this proved to be logistically impossible. The use of abstracts can produce highly satisfactory results in bibliometric analyses, since they usually contain all relevant information (Azevedo *et al.* 2010).

Eight-hundred-and-thirty articles were rejected from our database (many from other marine animals, marine pollution, fresh-water turtles and fishery). Thus, our study was finally based on 3,374 abstracts. In EndNote X7© we manually organized the references by groups according to the studied species. The groups were exported in .XML format to Microsoft Excel 2010© to filter the results accordingly to our objectives.

In *The Web of Science*© platform is possible to analyze the results according to some categories. We selected eight categories available: (1) year of publication; (2) type of publication (article or review); (3) author; (4) country (based in author's addresses); (5) Institution (organization); (6) subject area (using *The Web of Science*© categories; ex.: ecology, zoology, conservation, etc.); (7) language; and (8) funding agencies. We exported the results to Microsoft Excel10© to work on spreadsheets and used Minitab 17© to do Spearman rank correlations between two groups of data. A table with the number of nesting sites per country was available in Mazaris et al. (2014). We used a Spearman rank to check if the number of nesting sites is correlated to the number of publications in each country. To analyze three or more groups of data we created General Linear Models (GLM) in R (R Core Team 2016). To analyze if the number of publications was influenced by the year of publications and decade of publications, we created a GLM using the year and decade of publication as explanatory variables and number of published papers as response variable (model of distribution: quasipoisson). Contrast analysis was run to evaluate in which decade publications concentrated. To understand if the economy status of the country influenced in the number of articles published; we created another GLM using the Gross

Domestic Product (GDP) and the economic region of the countries as explanatory variables and the number of published papers as a response variable (model of distribution: quasipoisson). Contrast analysis was run to evaluate in which region publications concentrated. The GVP table by country and region is available in World Bank database <http://data.worldbank.org/indicator/NY.GDP.MKTP.CD>.

We did secondary analysis with the publications of the three less studied species, to understand its lack of knowledge. Checksheets were made to classify the articles in (1) areas of research (e.g. biology, ecology, zoology, conservation, etc.); (2) subareas of research (e.g. reproductive, behavior, migration, threats [pollution, fishing], etc.) and (3) stage of development (e.g. adults, juveniles or hatchlings/eggs [subadults were considered as juveniles]). Especially for Olive ridleys, we added (4) type of reproduction (e.g. solitary, arribada or both). When it was not possible to identify the classes, we classified data as Not Available (NA).

## Results

The number of articles published in marine turtle research has increased in the past 30 years (Fig. 1), showing a significant positive correlation between year and number of articles published (*rs* =0.990; N=30; p<0.0001). The year of 2016 was excluded from the analysis because publications were downloaded in July, which could underestimate the number for this year. There was a significant difference on the number of publications between all decades (GLM: F=99.99; p<0.0001), and a contrast analysis showed a concentration on the third decade (2006-2015), with a big increase in the number of publications (Fig. 2).

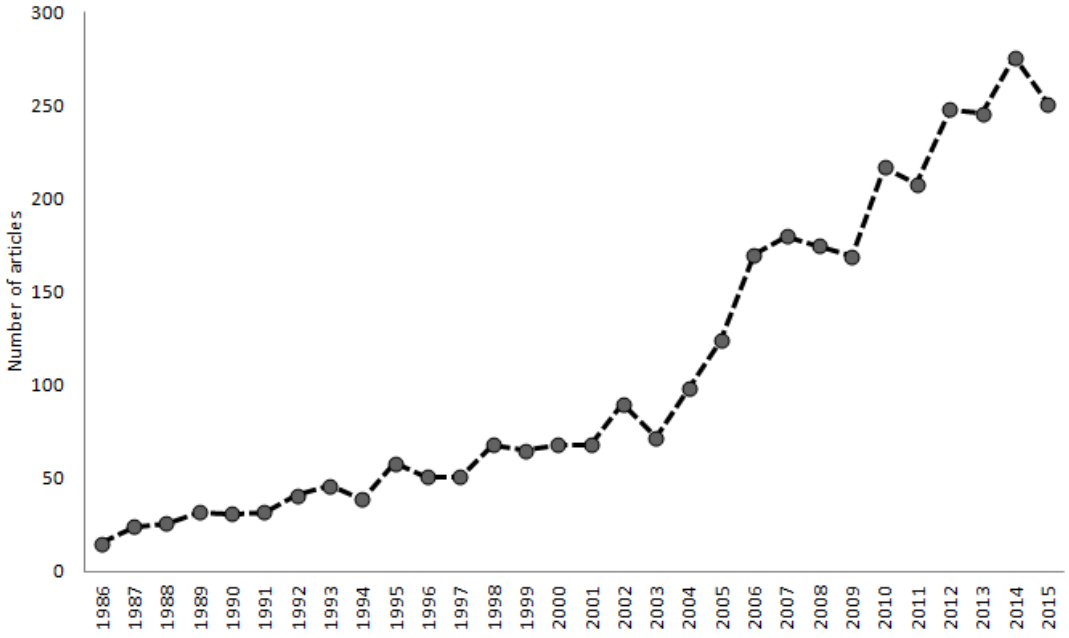


Fig. 1. Number of articles present in *The Web of Science*© database between 1986 and 2015 for marine turtle research.

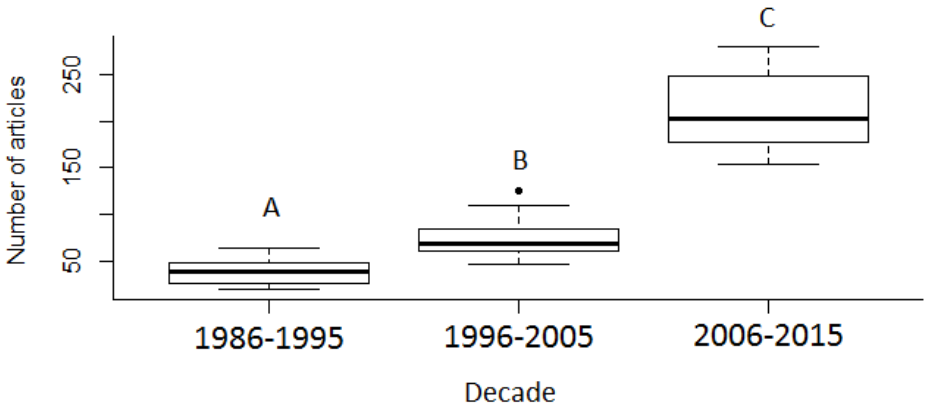


Fig. 2. Number of articles by decade present in *The Web of Science*© database between 1986 and 2015 for marine turtle research. Different letters means statistical differences.

Since only articles and reviews entered in our analysis, we tested the number of articles (N=3,259; 96.59%) per review (N=115; 3.4%); which showed that one review is made to every 28.3 articles.

In total, 6,206 authors have written the 3,374 articles. Two-hundred authors have written ten articles or more, and three authors have more than one-hundred publications each. They are Godley, B. J. (4.26%; N=144); Hays, J. C. (3.55%; N=120); and Broderick, A. C. (3.11%; N=105). The top twenty authors together detain 39.59% of all publications (N=1,336).

The authors came from 135 different countries. Since every author on the publication count as a unit in this analysis, the first 20 countries detain 125% of the articles published (N=5,113; Fig. 3). The publications are highly concentrated in North America, with the United States of America (USA) on the head line (48.25%; N=1,628). Following the downline there is Australia (13.66%; N=461); England (6.93%; N=234); Italy (6.34%; N=214); Spain (5.66%; N=191); Brazil (5.15%; N=174); and Mexico (5.06%; N=171).

To understand if USA was a significant contributor in other countries' publications, we ran the analysis again using the six subsequent countries with more publications after USA. In Figure 4 we showed the amount of publications that USA coauthors with these countries, and USA is in the first position of coauthoring in five of the six countries. Authors from USA are present in more than fifty-percent of the total articles in Mexico (50.29%; N=86), thirty-percent in England (33.33%, N=78), twenty-five-percent in Australia (28.2%; N=130), twenty-percent in Brazil (20.11%; N=35), thirteen-percent in Italy (13.08%; N=28) and thirteen-percent in Spain (13.08%; N=25).

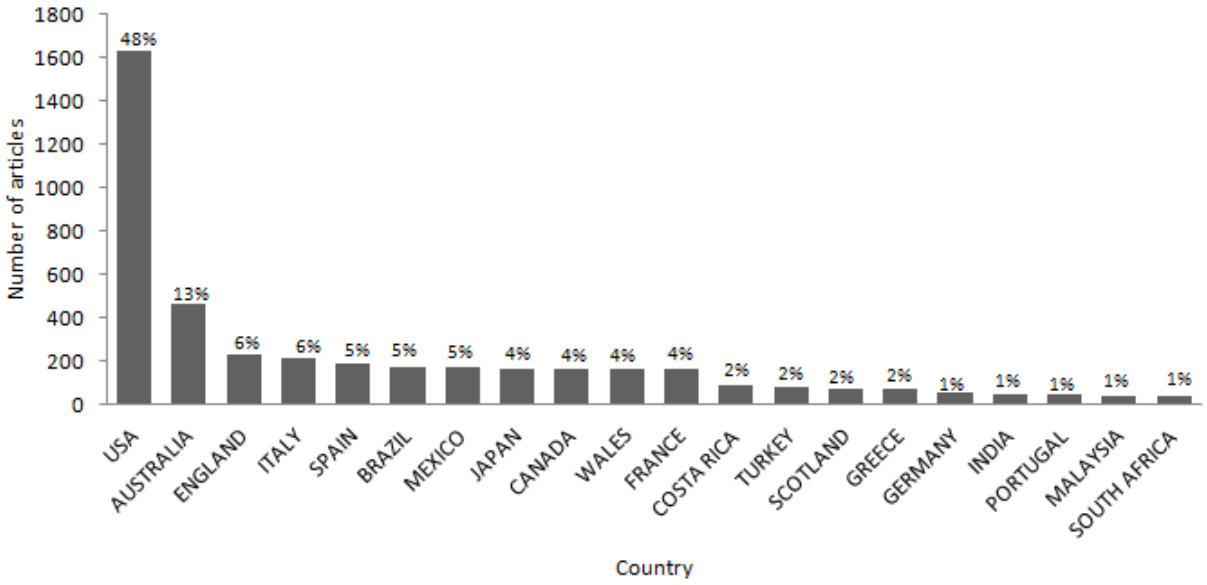


Fig. 3. Number of articles by country of the author present in *The Web of Science*© database between 1986 and 2016 for marine turtle research.

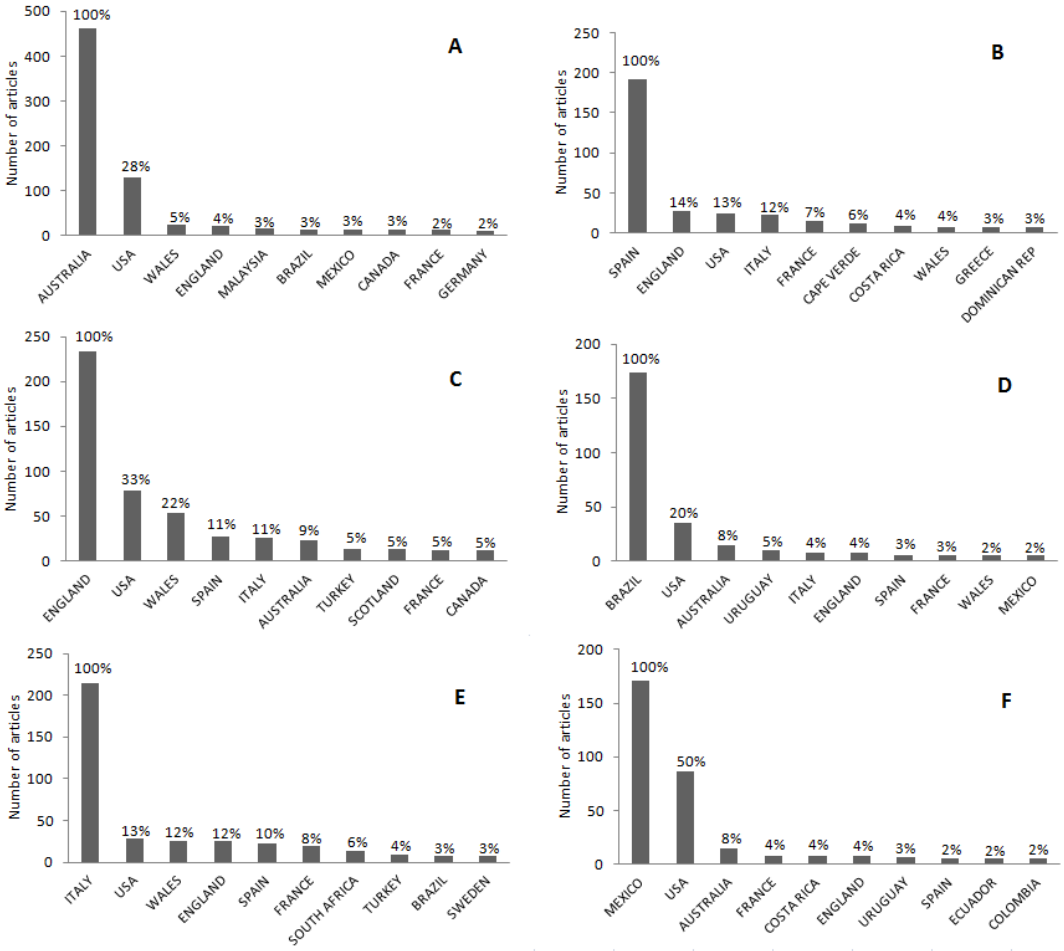


Fig. 4. Number of articles published by country highlighting the coauthoring of United States of America (USA) in (A) Australia, (B) Spain, (C) England, (D) Brazil, (E) Italy and (F) Mexico; in articles present in *The Web of Science*© database between 1986 and 2016 for marine turtle research.

The number of nesting sites is not correlated to the number of publications in each country (*rs*=0.135; p=0.097), but the number of articles published by country is influenced by its economic development and economic region (GLM: F=366.729, p<0.01; F=17.028, p<0.0002). A contrast analysis confirmed the concentration of publications in North America.

Two-thousand-and-ninety-six organizations were related to the authors and articles of our search. With relation to ten or more articles we had 198 organizations. With more than ten-percent of the publications related we had National Oceanic Atmospheric Administration (NOAA) (13.04%;

N=440) and Florida State University System (FSUS) (11.85%; N=400), both from USA. The top ten organizations together were related to 58.74% of all publications (N=1,982; Fig. 5).

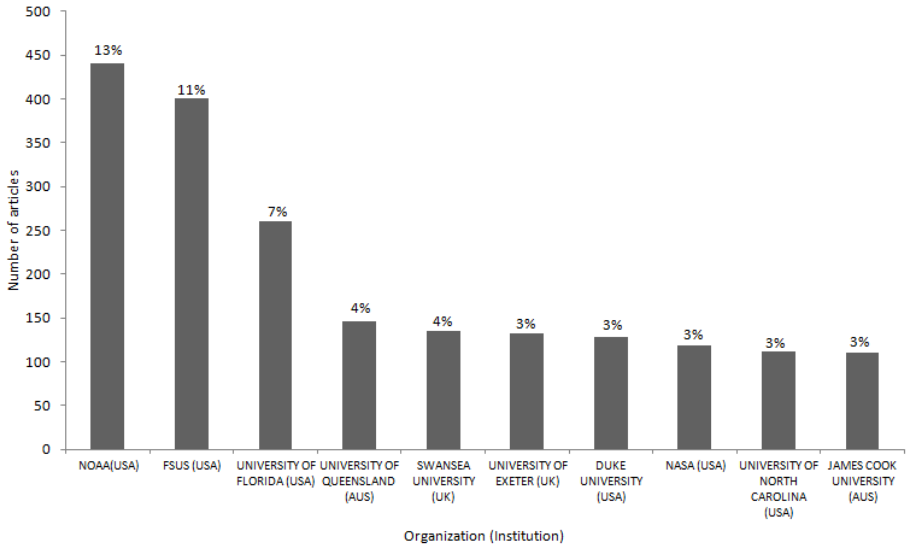


Fig. 5. Number of articles published by organizations present in *The Web of Science*© database between 1986 and 2016 for marine turtle research. NOAA= National Oceanic and Atmospheric Administration; FSUS= Florida State University Schools; NASA= National Aeronautics and Space Administration; USA= United States of America; UK= United Kingdom; AUS= Australia.

Publications were written in nine languages, almost all in English (97.57%; N=3292). There were thirty-seven publications written in Spanish (1.09%); sixteen in French (0.47%); twelve in Portuguese (0.35%); and eleven in Japanese (0.32%). The other languages had less than 0.1% of the total (N=3,374).

The articles were classified in 120 different categories according to *The Web of Science*©. Many articles were classified in more than one category, and that is why only the first five categories are responsible for 95.9% of all publications (N=3,236). The three most prominent areas of study are Ecology (25.63%; N=865), Marine Freshwater Biology (23.2%; N=783), and Zoology (22.91%; N=773). Following the downline there were Environmental Sciences (13.54%; N=457)

and Biodiversity Conservation (10.61%; N=358). The distribution of articles by subject area (with more than one-percent of publications) is shown in Figure 6.

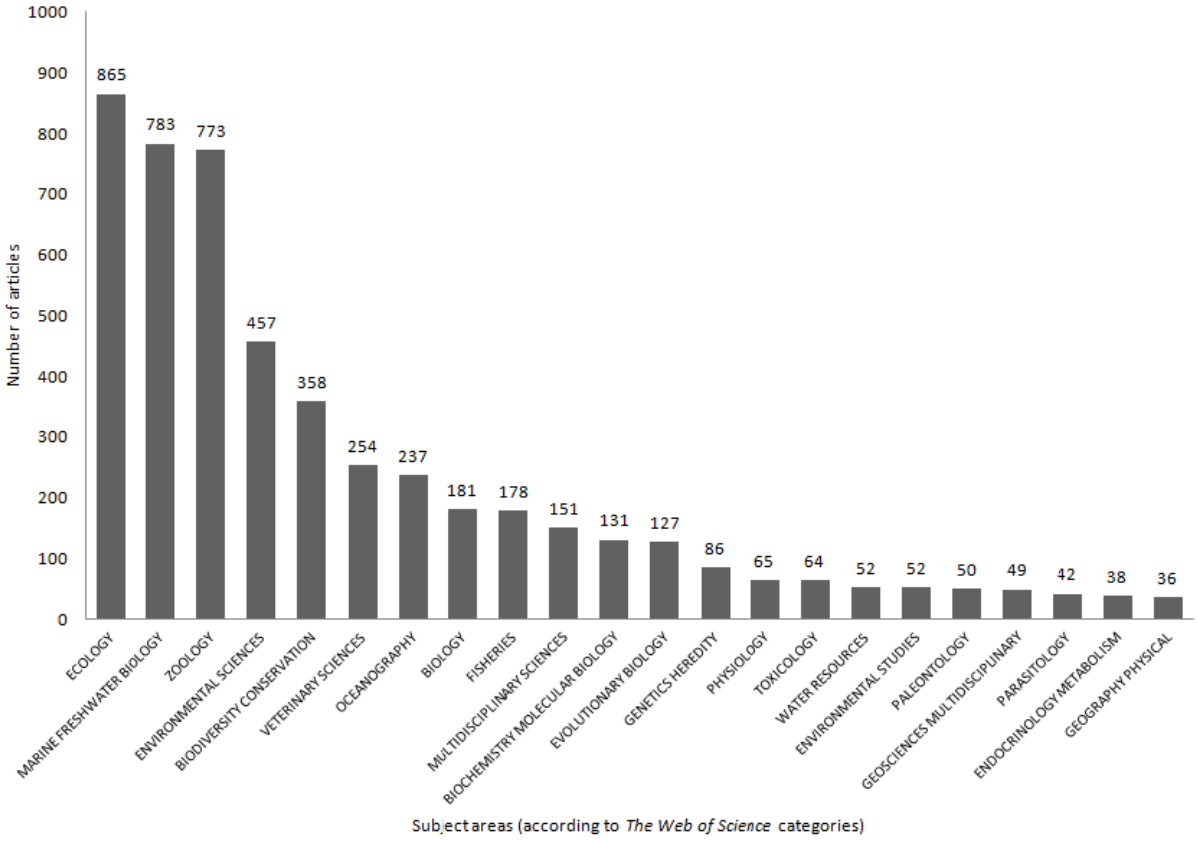


Fig. 6. Number of articles published by subject areas present in *The Web of Science*© database between 1986 and 2016 for marine turtle research.

More than sixty-two percent of the references were not related to funding agencies (N=2,092). Only eleven agencies funded thirty studies or more, six of them are from USA, two from United Kingdom (UK), one from Brazil and one from Canada (Fig. 7). To understand how the relation between funding agencies and organizations can impact the number of publications of a developing country we used Brazil as an example. This country has a huge conservation program that is responsible for monitoring almost all nesting sites, the Projeto Tartaruga Marinha (TAMAR) (in English: Marine turtle Project). Seventy four publications (42.52%) are attached to this project, but only ten publications (5.74%) are funded by it; but when we observe the

universities, they are attached to 93.1% of publications (N=162) and fund 81.6% of them (N=142; Fig. 8).

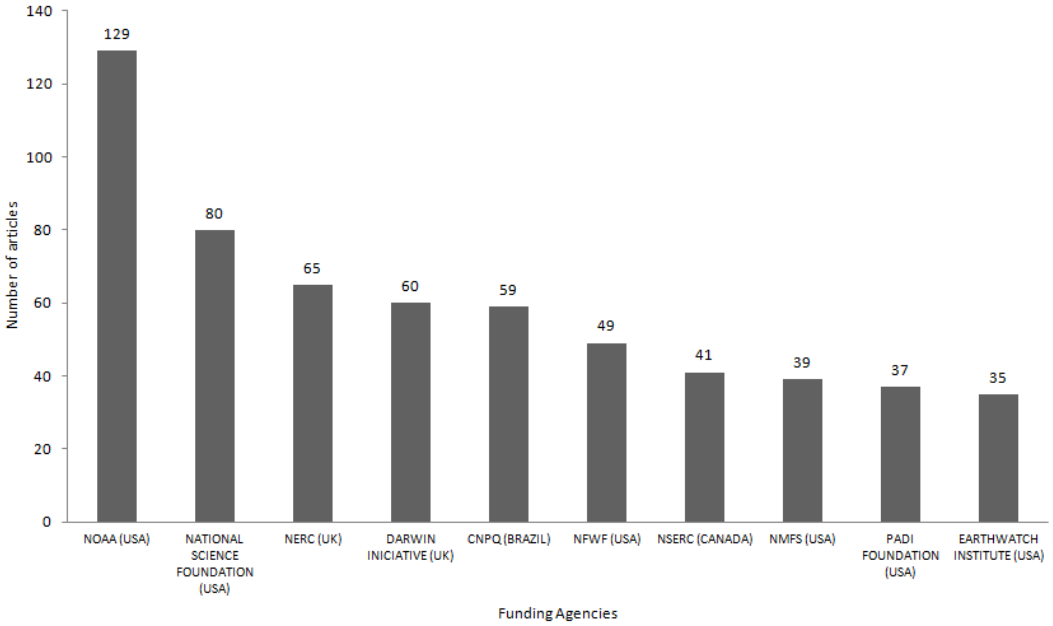


Fig. 7. Number of articles funded by agencies present in *The Web of Science*© database between 1986 and 2016 for marine turtle research. NOAA=National Oceanic and Atmospheric Administration; NERC= National Environment Research Council; CNPQ=National Counsel of Technological and Scientific Development; NFWF= National Fish and Wildlife Foundation; NSERC= Natural Sciences and Engineering Research Council of Canada; NMFS= National Marine Fisheries Service; PADI=Professional Association of Diving Instructors; USA=United States of America; UK=United Kingdom.

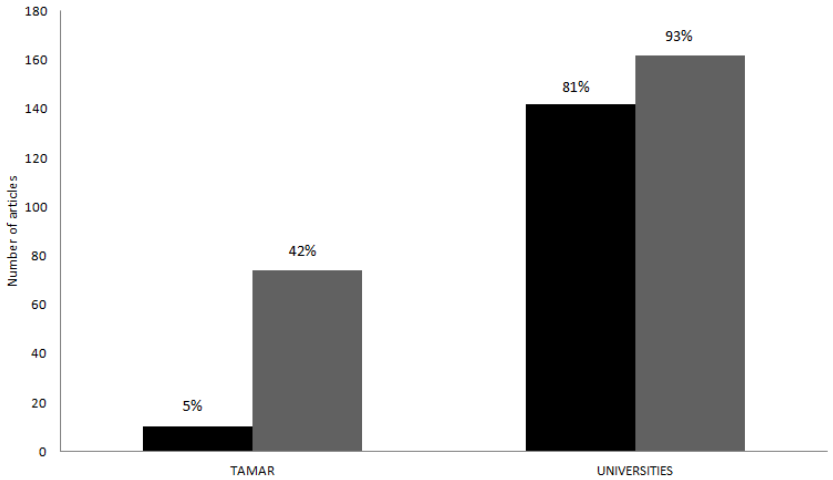


Fig. 8. Number of articles by funding (black columns) and authoring (gray columns) of TAMAR project and Universities from Brazil, present in *The Web of Science*© database between 1986 and 2016 for marine turtle research. TAMAR = Projeto Tartaruga Marinha (in English: Marine Turtle Project).

In 657 abstracts (19.47%), it was not possible to identify the species studied, and 422 (12.5%) publications studied more than one species. Ninety-one studies were about Paleontology, and were not classified by species. Nine studies were about hybrid individuals or populations, and if it was clear what species were involved in the hybridizations, the article was classified in the species group. The Loggerhead turtle (*C. caretta*) was the species with more publications related, with the amount of 1,145 articles (33.93%). Green turtle (*C. mydas* and outdated classifications of morphotypes *C. mydas agassizi*, *C. agassizi* and *C. mydas japonica*) was the second species with more articles, 1,062 (31.47%). The two species together were present in 65.4% of all publications (N=2,207). All other species summed were cited in 1,163 studies (34.46%), but with a big difference between each one. Leatherbacks were studied in 438 articles (12.98%); Hawksbills in 299 articles (8.86%); Olive ridleys in 221 articles (6.55%), Kemp's ridleys in 156 articles (4.62%) and Flatbacks in only 49 articles (1.45%) (Fig. 9). Global number of nesting sites by species was available in SWOT; we used this data to do a Spearman rank and check if the number of publications was correlated to the number of sites of each species, and we founded no correlation ($rs$=0.714; p=0.071).

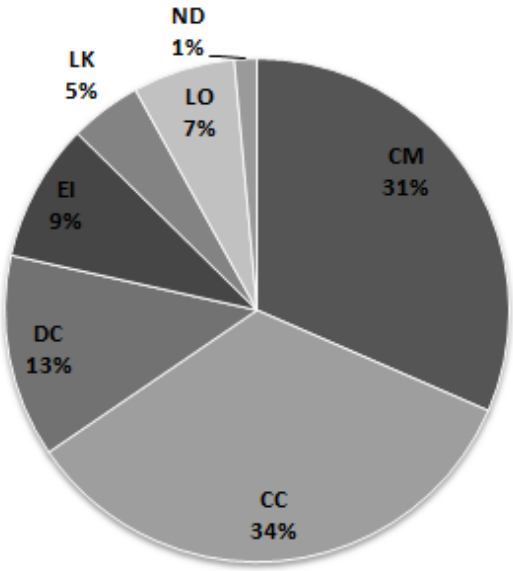


Fig. 9. Rounded percentage of articles published by marine turtle species studied present in *The Web of Science*© database between 1986 and 2016 for marine turtle research. CM=*Chelonia mydas*; CC=*Caretta caretta*; DC=*Dermochelys coriacea*; EI=*Eretmochelys imbricata*; LO=*Lepidochelys olivacea*; LK=*Lepidochelys kempii*; ND=*Natator depressus*.

Analyzing the percentage of articles by species per year of publication, we observed that the beginning of the second decade (1996) had a more equal distribution in the number of articles per species. *N. depressus* only appears in 1993, and always with less than five percent of representation. *L. kempii* had a decrease in percentage along the years, being more representative on the first decade; the peak observed in 2005 is due to a special edition with eighteen articles published for this species in the Journal of Chelonian Conservation and Biology. *L. olivacea* and *E. imbricata* presented a general increase in papers along the years, being more representative in the last decade. *D. coriacea* had a bigger representation in the first and in the last decade, with a decrease in the middle decade. *C. caretta* and *C. mydas* presented a slight decrease and a slight increase respectively, but they were always the most representative species on the studies in all decades (Fig. 10).

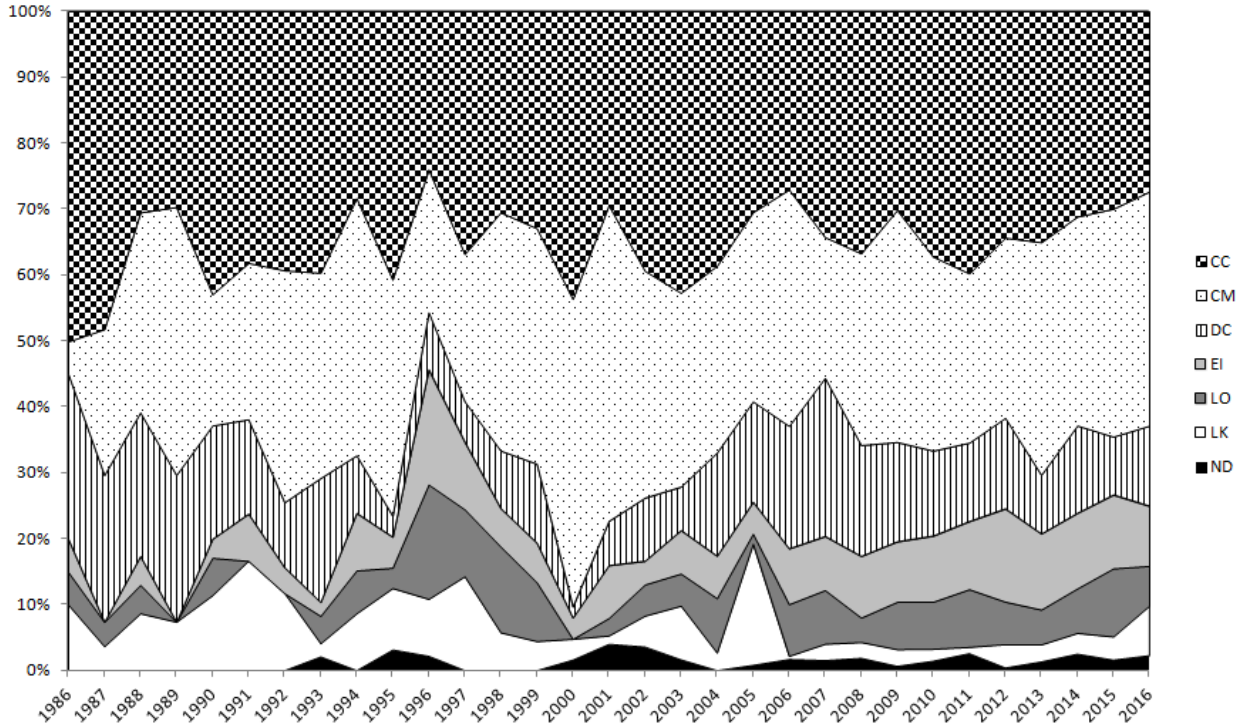


Fig. 10. The distribution of marine turtle articles present in *The Web of Science*© database between 1986 and 2016, according to the species studied, these being: *Caretta caretta* (black squares); *Chelonia mydas* (black dots); *Dermochelys coriacea* (vertical lines); *Eretmochelys imbricata* (light gray); *Lepidochelys olivacea* (dark gray); *Lepidochelys kempii* (white) and *Natator depressus* (black).

The publications trends of the four most studied species were analyzed in *The Web of Science*© platform, according to its categories. In general they followed the line showed in Figure 6, with Zoology, Ecology and Marine Freshwater Biology being the most studied areas in all of them (22 to 35%). Biodiversity Conservation is especially relevant in Hawksbill (19%; N=57) and Leatherback (14%; N=65) studies. Veterinary Sciences is a prominent area for Greens and Loggerheads (11 and 9% respectively); but is a gap on the other two (3 and 2%). Fisheries is more studied in Greens (4%; N=47) and Loggerheads (6%; N=78), less studied in Leatherbacks (3.8%; N=17); and is a gap in Hawksbills (1%; N=4). Oceanography appears with 6 to 8% in all of the four species. Genetics Heredity and Evolutionary Biology is better documented in Hawksbills with 6 and 4% respectively. On the other three species is a general gap that varies

between 2 and 3%. Behavioral Sciences are considered as a gap for all species, with only 1% in each one.

On the 49 abstracts that contemplated Flatbacks, 15 studied adult subjects (30.61%), 32 studied hatchlings/eggs (65.3%), and none studied juveniles (Fig. 11). In ten abstracts (20.4%), it was not possible to identify the stage of development of the studied subjects. In 13 of the 30 years analyzed there were no publications about Flatbacks (1986-1992, 1994, 1997-1999 and 2004-2005), and the year with more publications was 2014, with seven papers (14.28%); the mean of publications per year was 1.54 for this species. We did a Spearman rank (excluding the period 1986-1992) and founded a significant positive correlation between year and number of articles published ($rs$=0.648; N=24; p=0.001). The most prominent area of research with Flatbacks was physiology (16.32%; N=8), followed by reproductive studies (12.24%; N=6). With four articles each we had behavior, migration and conservation studies (8.16%). Three articles studied pollution (6.12%) and the other areas had two or just one article each. It is relevant to mention that just one author (Hewavisenthi, S.) has five articles published, all reproductive studies analyzing incubation of eggs in different environments.

*L. olivacea* had a similar distribution of studies between adult and hatchlings/eggs stages (32%, N=72, and 35% N=49). Juveniles are less studied, with only seven percent of publications (N=17; Fig. 11). There were 86 abstracts (38.9%) in which it was not possible to identify the stage of development of the turtles. About the type of reproduction, we observe that twenty-six percent of the studies were about solitary nesters (N=58), seven percent about arribada nesters (N=17) and thirteen percent of the studies contemplated both types of reproduction (N=29). In more than fifty percent of the abstracts (N=117) it was not possible to identify the type of reproduction (Fig. 12). The most prominent area of research was reproductive (23.98%, N=53),

followed by threats (18%, N=40). Veterinary and biochemistry were the areas with almost no papers published.

Differently from the two former species, the most studied stage of Kemps' ridley is juveniles, with 34% (N=53) of publications, then adults with 24% (N=38) and hatchlings/eggs with 16% (N=25). There was not possible to identify the stage of development in 66 abstracts (42.3%; Fig 11). The most prominent area of research was veterinary, with 23 articles (14%), ten of them about coldstunned turtles. We then had physiology and conservation with 12% each (N=20, N=19). There was only one study about biochemistry, and there were no studies about predation.

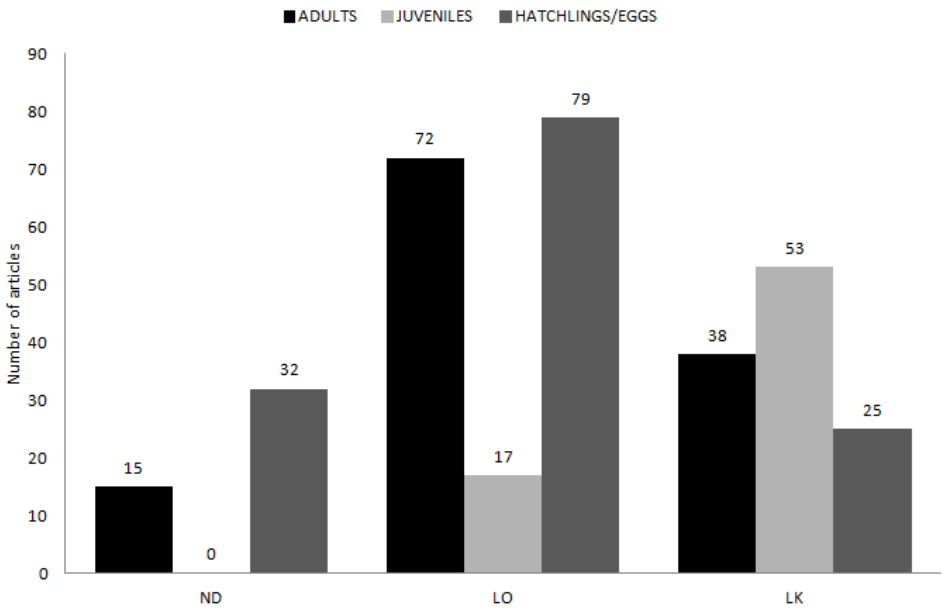


Fig. 11. Number of articles by stage of development and specie studied, present in *The Web of Science*© database between 1986 and 2016 for marine turtle research. ND= *Natator depressus*; LO=*Lepidochelys olivacea*; LK=*Lepidochelys kempii*

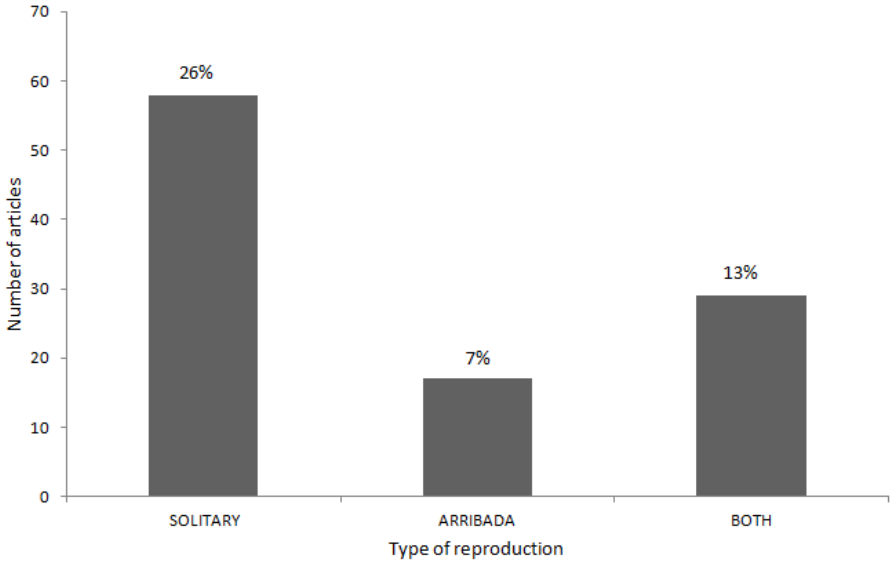


Fig. 12. Number of articles by type of reproduction of *Lepidochelys olivacea*, present in *The Web of Science*© database between 1986 and 2016 for marine turtle research.

## Discussion

Marine turtle research has grown rapidly, especially on the last decade. On the 80's decade, huge marine turtle conservation programs were starting around the globe (Marcovaldi and Marcovaldi 1999; Martínez *et al.* 2007). Considering that evaluation of trends in sea turtle nesting populations requires many years of data because of the large degree of annual variation in nesting numbers (Bjorndal *et al.* 1999), data from this projects probably started to be effectively published in the last decade, increasing the total number of publications in it. In spite of the growth in number of published articles through decades, the species are not being studied in the same proportion.

The lack of knowledge concentrates especially in the Flatback turtle. This species is unique because it does not have a pan-oceanic distribution (Walker and Parmenter 1990), being endemic of Australian coast (Parmenter and Limpus 1995), and it is the only species of marine turtle that lacks an oceanic phase of development in its early life history (Salmon *et al.* 2010). Australian conservation authorities recognizes the need to increase census and demographic data for Flatback turtles since 2006 (Schäuble *et al.* 2006), but only two studies were published in this area after that (Whiting *et al.* 2008; Pendoley *et al.* 2014). We know little about the threats that impact this species as well, since ingestion of debris was reported only once (Schuyler 2014); contamination was reported only twice (Ikonomopoulou *et al.* 2011; Ikonomopoulou *et al.* 2012); light pollution twice (Kamrowski *et al.* 2014, Pendoley *et al.* 2016); industrial development once (Whittock *et al.* 2014); and there wasn't a single study about bycatch fishing. The consequence of this lack of knowledge is demonstrated in Flatback turtle conservation status, which is still Data Deficient. There is an urgent need to publish studies about its juvenile phase (there wasn't any study about them in our search), but we highly encourage scientists to

study this specie in all aspects. Only with investment on studies about this specie would be possible to do an assessment about its conservation status.

Contrarily to previous studies of Olive ridleys, that say that arribadas have been relatively well documented compared to limited information of solitary nesting (Matos *et al.* 2012), our study founded that solitary nesters are more well documented than arribada nesters. This result reflects that rookeries with non-arribada behavior are many times more numerous than those that nest as arribadas (Abreu-Grobois and Plotkin 2008), and that is easier to manage few turtles nesting and few nests than even small samples from thousands of turtles or nests. The most prominent area of research in this specie reflects the curiosity of researchers in its special behavior; reproductive studies only lost to threats studies. Reproductive studies are probably more abundant because monitoring sea turtles is easier during their terrestrial life-history phase, during nesting activity (Seminoff and Shanker 2008). The inaccessibility of open ocean habitat and the cryptic nature of smaller animals are fundamental problems when assessing oceanic-stage of sea turtles (Putman *et al.* 2013).

On the opposite way of the last two species, Kemps' ridley juveniles are more studied than the other stages. First because they inhabit USA waters (Burke *et al.* 1994); second because they frequently forage off to northern waters in summer, and when they do not come back in autumn, they are exposed to decreasing water-temperatures and may become ''coldstunned'' (Burke *et al.* 1991). This stress makes them cease swimming, float on the surface of the water, and become stranded (Shwartz 1978). These turtles are rescued to rehabilitation centers, making captive veterinary studies possible; that is why this is a prominent area of research in this specie.

Rehabilitation centers are not common in developing countries, but there are several visitation centers of environmental education that have captive turtles for exhibition. Only in Brazil there are at least seven visitation centers with captive turtles (TAMAR 2016), and these turtles' behaviors are not studied. Environmental enrichment, for example, was studied only once for sea turtles (Therrien *et al.* 2007), showing that this is a promising area of study for captive marine turtles of all species.

Taking in count that the number of nesting sites is not related to the number of publications and that the economic status of the country is related to its relevance on publishing, there is a huge disparity between publishing countries. This shows that scientists from more developed countries (especially USA) are doing their researches abroad, but still attached to their homing country universities. This situation leads us to advise the developing countries: they need more government funding in universities and conservation programs, giving the opportunity to local researchers to study the sea turtles in their own country.

Monitoring nesting sites of marine turtles requires a lot of money and personnel, and in several times is maintained by conservation projects. Costa Rica is the country with more projects, the majority of them held by donations and volunteering (Ellis 2003), with Tortuguero being the oldest, with more than 60 years of researches (Troëng and Rankin 2005). Even though, Costa Rica does not appear even on the first ten countries with more publications. In more recent projects, the situation is worse, for example, in the Restoration Project of Marine Turtles (PRETOMA), that started monitoring sea turtle nesting activity on the southern Nicoya Peninsula of Costa Rica in 1998 (Beange *et al.* 2015). Not a single publication was found attached to this project.

This highlights another problem in marine turtle research in developing countries: they have big amounts of data collected, but few were analyzed and published. One thing that leads to it, is the poor inspection made by the funding agencies that supports the conservation projects. The projects are focusing on environmental education and volunteering and forgetting about the academic part of publishing their data. A possible solution is to make partnerships between these projects and Universities. In this way, projects that are not capable of paying qualified people to analyze their data can allow University researchers to scrutinize and publish their data. We do need a better inspection from organizations and funding agencies that are affording this conservation projects. They need to know where the money was invested and charge a response in the form of high quality publications, not accepting only local papers and symposium abstracts and presentations.

We conclude that although the number marine turtle publications are increasing along the years, more efforts should be directed to the three less studied species. Taking in count that two of them have restricted ranges of distribution, this effort is urgent to make conservation assessments and decisions possible and effective. In general, there is a tendency in researchers to follow the areas with more bibliography available, but sometimes it is necessary to swim against the current. We need to fill the gaps that were presented on this article, generating high quality publications in marine turtle research. In this way we will facilitate the assessments for all species, not basing them on personal communications and grey literature.

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