Leatherback nest ecology in the Gamba Complex: implications for a successful hatchery and sustainable conservation

Gabon, Central Africa

2007

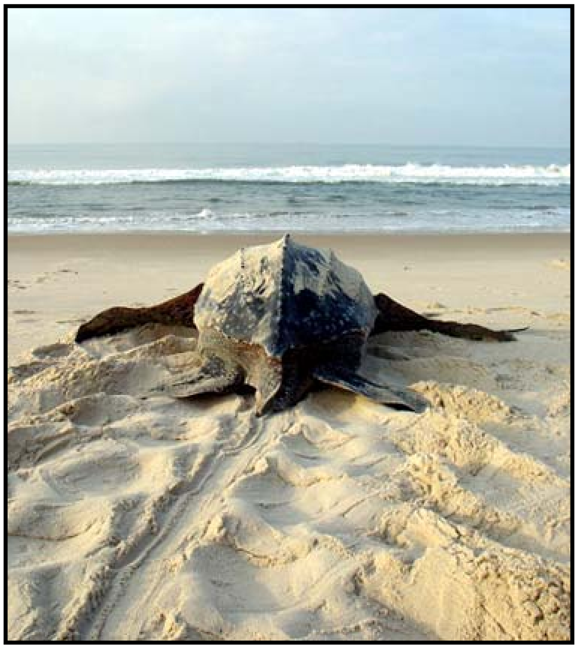

Photo: Leatherback returning to sea on Gamba beach, Gabon (S.R. Livingstone)

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2. Acknowledgements

Thank you to the project funders: The British Chelonia Group, The Carnegie Trust, The Rufford Foundation, The Glasgow Natural History Society and the Percy Sladen Memorial Fund for making this project possible. I wish to thank WWF Gamba (especially Bas Huijbregts and Bas Verhage) and IBONGA (Hans Maguya and Jean-Pieer Baye) for supporting the project and for technical assistance in the field.

Thanks to the 2005/06 Gamba turtle team: Eustache, Aubin, Mourchid, Hervie, Jean Pierre, Davy, and especially to James Levi who worked so hard on the beach. Many thanks to the friends I made at the Shell Gabon Yenzie camp for their assistance in the field and friendship (and who helped me escape from the beach once in a while). Special thanks also to Sarah Matthews for making my time in Gabon much more fun.

Thank you to the University of Glasgow (Professor Roger Downie) for support and the loan of technical equipment. I wish to thank Angela Formia and Manjula Tiwari for advice and support throughout the project, and to Sarah Humphries for her encouragement.

Thanks also to the Sea Turtle Symposium Committee and donating organisations for awarding a travel grant to assist with the presentation of this research at the Annual International Symposium on Sea Turtle Conservation and Biology in Crete, Greece in April 2006.

Photographs by S. R. Livingstone

3. Resulting publications

Some of this work was presented at the Annual International Symposium on Sea Turtle Conservation and Biology in Crete, Greece in April 2006.

Livingstone, S.R. and Verhage, S.B. 2006. Leatherback nest ecology in the Gamba Complex, Gabon: Improving hatchery output. Proceedings of the 26th Annual International Symposium on Sea Turtle Biology and Conservation (Crete, Greece), pp.143.

The results presented here are also incorporated into a WWF publication posted on the WWF website which has been widely distibuted within Gabon and Central Africa.

Verhage, B., Eustache, B.M. and Livingstone, S.R. 2006. Four Years of Marine Turtle Monitoring in the Gamba Complex of Protected Areas Gabon, Central Africa, 2002-2006. WWF Publication.

http://assets.panda.org/downloads/wwfgabon_marine_turtle_report_four_years.pdf

The results from this research are planned for at least two further articles in peer-reviewed journals (one manuscript is currently under review in Testudo; journal of the British Chelonia Group).

4. Project funding and expenditure

Project Funding

Funding body	Grant (£)
British Chelonia Group	£500.00
Carnegie Trust	£1,500.00
BLB (Glasgow Natural History Society)	£400.00
Rufford Foundation	£3,007.00
Percy Sladen Trust	£690.00
TOTAL	**£6,097.00**

Project Expenditure

Item	Cost (£)
International travel (flights and visa)	£1,286.00
Travel Insurance	£183.75
Project administration and reports	£176.00
WWF office facilities (WWF - in kind)	£0.00
WWF Gamba accommodation (WWF - in kind)	£0.00
Health (Vaccinations and Malaria pills)	£284.00
In-country travel	£227.00
In-country communication (field phone + call credit)	£383.00
Salary for field guides	£1,600.00
Fuel (for field quad bike)	£306.00
Subsistence (personal and field guide contributions)	£464.00
*Field Equipment	£1,456.00
Laptop (Glasgow University loan - in kind)	£0.00
Temperature sensors (Glasgow University loan - in kind)	£0.00
TOTAL	**£6,365.75**

(Project over budget by £268.75)

*Field equipment included: tent, field callipers x 2, spring balances x 2, building materials for hut at camp, stop clocks x 2, measuring tapes x 2, field rucksacks x 2, sledge hammers x 2, tools for field camp, shovel, metal wire for nest protection, buckets x 8, umbrellas x 6, batteries, mosquito net, rubber gloves, string and electrical tape.

5. Study Area

5.1 The Gamba Complex of Protected Areas

The Gamba Complex of Protected Areas is situated in south-western Gabon along the Atlantic coast and extends over a total area of 12,000 km^2 (figure 5.1). The Complex contains a mosaic of different habitats including seashores, mangroves, coastal forest, swamp forest, equatorial rainforest, semi-montane forest, savannas, rivers, lagoons and swamps. Gabon's littoral coastline consists mainly of long sandy beaches, interspersed with small rocky sections.

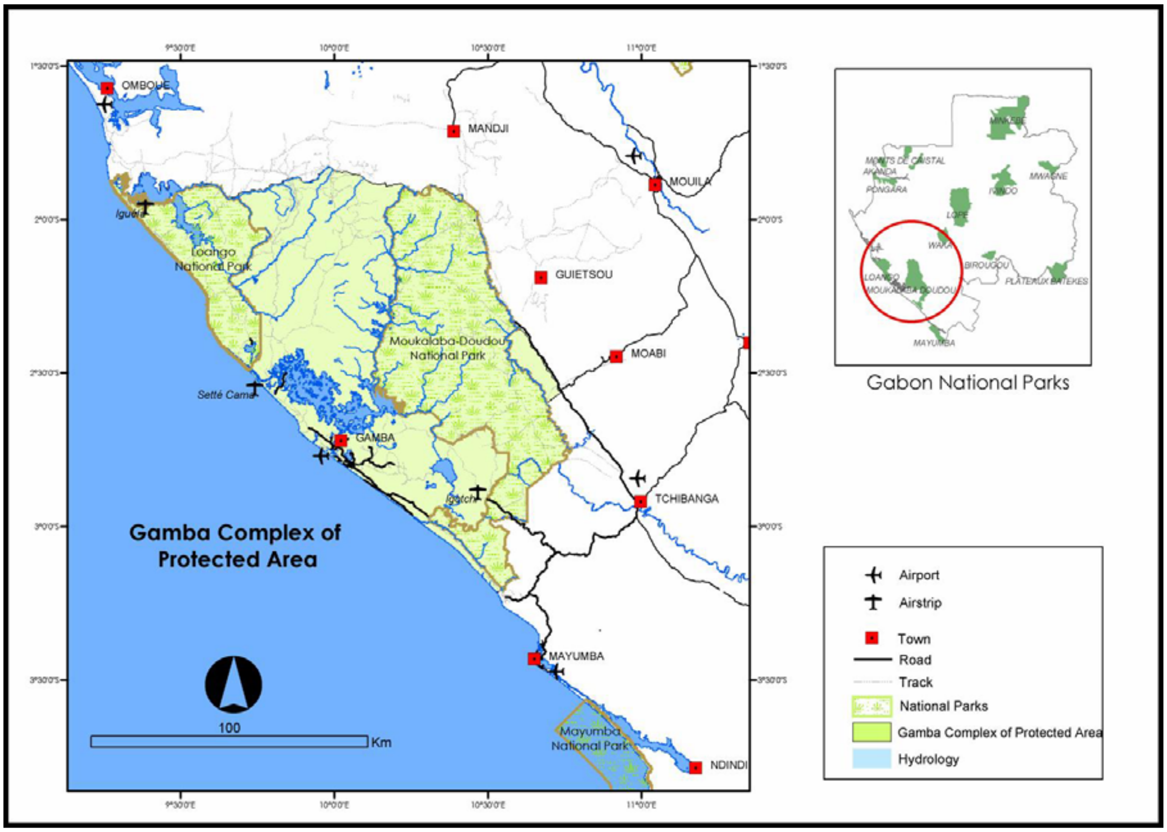

Figure 5.1 – Gamba Complex of Protected Areas

The wildlife in the area is abundant and high densities of large mammals such as forest elephant, forest buffalo, red river hog, gorilla and chimpanzee have been recorded. Twelve species of forest antelope are present, and nine species of primates. The avifauna is represented by many spectacular species such as pelicans, ibises, hornbills, turacos and bee-eaters. A total of 470 bird species have been recorded, of which 80% are breeding residents. The widespread distribution of a variety of aquatic habitats favours the occurrence of all three African crocodile species, a number of fresh water turtles, manatee and hippopotamus. Offshore, marine mammals such as dolphins and whales are regularly sighted, and the coastal waters are a breeding ground for important populations of humpback whales. The beaches along the Gabonese coastline support the nesting of four species of marine turtle: leatherbacks, olive ridleys, greens and hawksbills, all of which are listed as threatened in the IUCN Red List (IUCN Red List, 2006).

The conservation value of the Complex was fully recognized in 1962, and is protected through eight defined areas. Two of the 13 recently created National Parks in Gabon are located within the Complex: Loango National Park (1,500 km^2) in the Northwest, and Moukalaba-Doudou National Park (5,000 km^2) in the eastern part. The Complex is considered to be of the best preserved landscapes of its kind in Central Africa. The beaches within the Complex are considered to be some of the most important nesting beaches for leatherback turtles in the world.

Some 9,500 people live within the Gamba Complex. About 7,500 people reside in Gamba town, which is located in the heart of the Complex. Gamba town is heavily linked to the oil industry. Oil and gas exploration and production concessions are located in the reserves between the two parks and off-shore. A large oil export terminal, operated by Shell Gabon, is located on the coast near Gamba town. Some 30 small villages and settlements with populations ranging from 15 to 350 people are located within and around the Complex.

5.2 Gamba beach

The study site for this research is a 6 km section of beach located between the Shell Oil terminal and an area called ‘Pont Dick’ on Gamba beach. The beach ranges in width all along the study site. At the back of the beach, grassy lands spread onwards 20 to 30 m, with low plants completely covering the substratum (figure 5.2). Littoral thickets or low sometimes marshy forests grow before the lagoon areas bordering the shore.

Figure 5.2 - Gamba beach study area

The beach study area was marked out in 2002 by the WWF team. It was chosen for a number of reasons: it was known to be an area of high density nesting for marine turtles (leatherbacks in highest numbers, and olive ridleys), and the closeness to Gamba town with an access road to the beach (built originally for the oil terminal). The proximity to Gamba town offered relatively easy access for the work team, tourists, visitors and the local community. The Shell oil terminal is situated at the northwestern end of the project area which also allows the impacts of the terminal activities on the turtles to be investigated.

5.3 Marine turtle research in Gabon

Gabon's coastline is thought to support one of the largest leatherback (*Dermochelys coriacea*) nesting populations in the world. However, little research has been carried out in the region. The presence of marine turtles nesting in Gabon was first mentioned by Duméril (1860) in his report on reptiles in Western Africa. In 1984, Fretey (2000; 2001) later documented the Gabonese marine turtle nesting locations in more detail.

The WWF marine turtle project in Gamba is one of the three main areas in Gabon where marine turtle monitoring is ongoing. The other projects are based in Pongara and Mayumba (Wildlife Conservation Society (WCS); Aventures Sans Frontières (ASF); Gabon Environnement; Protection of Marine Turtles in Central Africa (PROTOMAC)) (Verhage et al. 2006). These organizations are currently part of a national marine turtle information network in Gabon, working together to provide consistent monitoring data on marine turtles from the different nesting beaches into one database (A. Formia, pers. comm.). Thus, enabling the Government to make informed decisions about this important national resource.

6. Research: Leatherback nest ecology and hatchery success

6.1 Introduction

Several aspects of leatherback nest ecology were investigated within the 6 km study area on Gamba beach. A number of nests were randomly chosen, marked and monitored throughout the incubation period during the month of December 2005 (2005/2006 season). The main aim was to gather baseline information on the nest and hatching success of leatherback nests, and to explore several aspects of the intra-nest environment. This information is important for determining the hatchling output of the beach relative to other important nesting areas in Gabon, and in other large nesting sites around the world. An assessment of the sources and level of threat to nests and hatchlings was also made in order to establish how best to manage the beach in terms of maximising hatchling output.

During the 2004/2005 season, some data were collected on the hatching success of in-situ leatherback nests (n=23) by the WWF team (Verhage and Moundjim, 2005). An open-air hatchery was also created and a number of nests placed in it (n=20) in an attempt to protect nests from the various threats that exist on the beach. The hatching success in the hatchery nests was also investigated. The results of the 2004/2005 study showed that the hatching success in the hatchery nests (46%) was significantly lower than in the in-situ nests (83%) (Verhage and Moundjim, 2005). It was suggested that this may have been due to high temperatures in the hatchery. In addition to this it was suggested that the methods used to translocate the eggs from the beach to the hatchery could have resulted in lower success.

One of the main aims of this project was to try to make improvements to the hatchery and increase hatchling output. An assessment of the value of relocating nests into the hatchery is made.

6.2 Research aims

- To examine nest and hatching success along with basic nest parameters in in-situ leatherback nests on the study area at Gamba beach
- To identify and assess the threats to leatherback nests and hatchlings
- To compare the nest and hatching success of in-situ nests with nests translocated to the hatchery, and to review translocation methods
- To train the local counterparts in nest excavation and translocation techniques to ensure a continuation of data collection for a sustainable project into the future
- To make recommendations for conservation measures for marine turtles nests laid on Gamba beach
- To develop methodology for collecting nest parameter data that can be used by all the marine turtle monitoring projects in Gabon to assist in collecting comparable data

6.3 Methods

In-situ nests

A total of 35 leatherback nests were marked at the time of clutch deposition and monitored through till hatching. These nests were randomly chosen over a three week period of beach monitoring (the nests were used on a "first come first served" basis during night time surveys). Detailed information on the nest position was recorded (beach zone, position in relation to the high water mark and the backing vegetation). Each nest was surrounded by a wire mesh and marked with a sign post (figure 6.1). This was to assist nest location and monitoring of the nests and to make beach visitors aware not to disturb the experiment rather than to protect the nests from predators – the mesh did not keep any of the natural predators out.

Temperature sensors were placed in to the centre of the clutch of eggs in 23 of the monitored nests at the time of deposition (figure 6.2). The sensors were set to take a temperature every hour during the incubation period (methodology refined in leatherback nests in Trinidad (Livingstone, 2006).

Figure 6.1 – Numbered and marked leatherback nest

Figure 6.2 – Gamba turtle team place temperature sensor in the nest

Once hatched, each nest was excavated and the contents were examined and recorded (see nest profile methods). The incubation period for each hatched nest was recorded. The nests that did not hatch were excavated three days after their due date to determine the cause of hatch failure. Information on a number of other nest parameters was also collected: depth to the top and bottom of the nest chamber and whether the nest had been subject to predation. The temperature sensors were removed from the nest, and the data was downloaded onto a computer.

In addition to the monitored nests, a random selection of in-situ hatched nests were excavated on the beach. The study site was checked during the early morning for any nests that had hatched the previous night. Nests were identified by an indentation in the sand (approximately 15 cm diameter), usually with hatchling tracks leading from it. Some nests were also identified by the presence of crab holes.

Hatchery nests

A total of 15 leatherback clutches were translocated to the open air hatchery. This was done using a technique refined in Trinidad (Livingstone, 2006), differing from the method used on the Gamba study beach in 2004/2005 season. The technique used in 2004/2005 involved digging up a nest the morning after it had been laid and transporting the eggs in a bucket to the hatchery where they were manually placed in pre-dug holes.

The 2005/2006 technique involved collecting the eggs in a thick plastic bag inserted into the empty nest seconds before the start of egg deposition (figure 6.3). The sand behind the nest was then dug out to facilitate easy removal of the eggs once the turtle had finished laying. The eggs were then transported immediately and placed in a pre-dug hole in the hatchery (figure 6.4). The eggs were never touched with human hands.

A temperature sensor was placed in the centre of each clutch of eggs placed in the hatchery. Each nest was excavated after hatchling emergence, and the data collected as for the in-situ nests.

Figure 6.3 – Nest deposition into a plastic bag

Figure 6.4 – Clutch transportation to hatchery

Nest profile methods

Each nest was excavated (figure 6.5) and the contents of the nest were sorted, counted and the clutch size was recorded (figure 6.6).

Figure 6.5 – Nest excavation

Figure 6.6 – Recording nest contents

The eggs were then divided up into categories. The eggs were initially categorized by their morphological features, and then by their contents. The egg types were: hatched (empty shell fragments from which a hatchling would have hatched and emerged from the nest), shelled albumin globs (SAGs) referred to in this study as 'inert' eggs (reduced in size with a clear viscous interior) (Bell et al., 2003) and un-hatched (complete full sized eggs) (figure 6.7).

Figure 6.7 – Nest contents sorted into types (hatched, SAGs and unhatched)

The unhatched complete eggs were opened, and classified into four further categories: non-fertilized (clear albumen with a clean and separate yolk), dead-in-shell (egg containing an embryo of any size which had died during development), bacterially infected (no clear embryo, with a yellow or pink material with a "cheesy" consistency and a particularly offensive smell), and disintegrated (containing a near fully developed hatchling that has started to disintegrate within the egg).

Each category of egg was calculated as a percentage of the total clutch.

Any live or dead (free from shell) hatchlings were also counted. Live hatchlings found in the nest were usually quite weak, and would not have been able to emerge from the nest on their own. They were allowed to make their way to the sea (figure 6.8).

Figure 6.8 – Excavation hatchling on its way to the sea.

Nest and hatching success

Nest success was defined as the percentage of nests that successfully hatch from the total number of nests laid (using the 35 monitored nests). A nest was classed as hatched if at least one hatchling emerged. The hatching success was defined as the percentage of fertile eggs that developed into hatchlings that fully emerged from the shell. This was calculated as a percentage of the viable eggs (total eggs - inert eggs).

The data from the in-situ nests were compared to those from the hatchery nests. The data from this study was also compared with that collected in 2004/2005. Mann-Whitney U tests were used to analyse the data (non-parametric data).

6.4 Results

In-situ nests

A total of 95 in-situ nests were excavated. The excavation allowed the contents to be examined and quantified, and some parameters of the nest environment measured. Only nests that produced at least one hatchling was used for this analysis. Data for completely failed nests were excluded. Figure 6.9 presents the mean percentage of each category of egg within the nests.

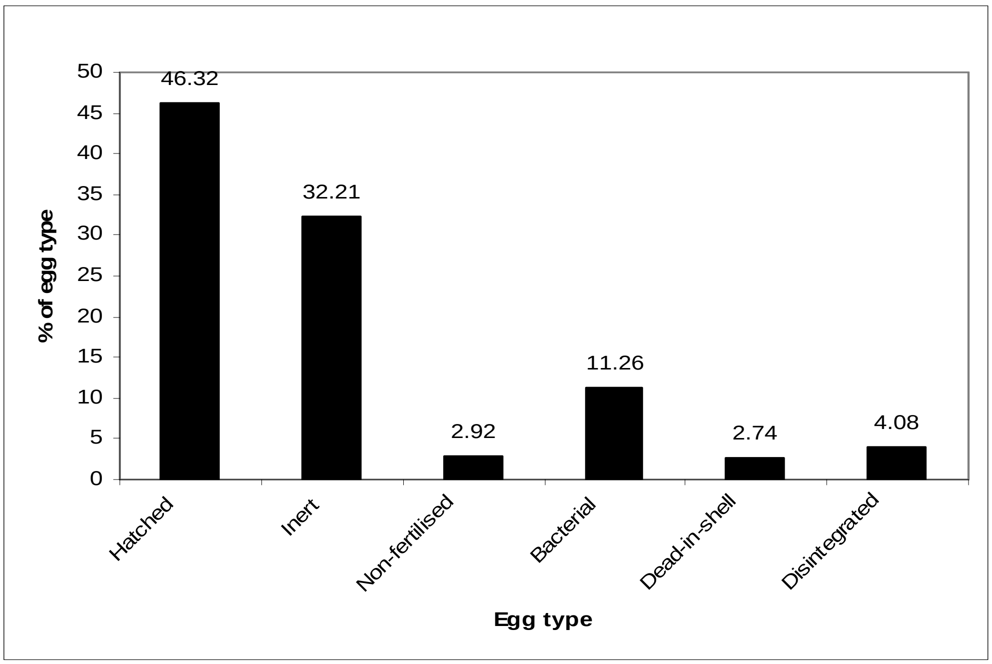

Figure 6.9 - The percentage of each type of egg in in-situ leatherback nests

The total mean number of viable eggs was 65.9 (n=95, SD=17.26) (total eggs – inert eggs) and the mean number of inerts was 31.5 (n=95, SD=14.6).

The mean depth to the top of the nest chamber was 73cm (n=95, SD=13.6) and the mean depth to the bottom of the nest was 90.7cm (n=95, SD=14.9).

The mean temperature inside the in-situ nests was 29.07°C (n=11, SD=0.26) and the average incubation period was 67.07 days (n=12, SD=2.26).

Out of the 35 in-situ leatherback nests that were monitored throughout the incubation period, 19 of them produced at least one live hatchling. The nest success was **54%.**

The 46% of nests that did not hatch were dug up and the cause determined. 56% of the nests were destroyed by crab predation (n=9), 25% of the nests were inundated by the sea (n=4) and 19% of the nests were attacked by invading roots at the back of the beach (n=3) (figure 6.10). No human poaching was witnessed on the study beach.

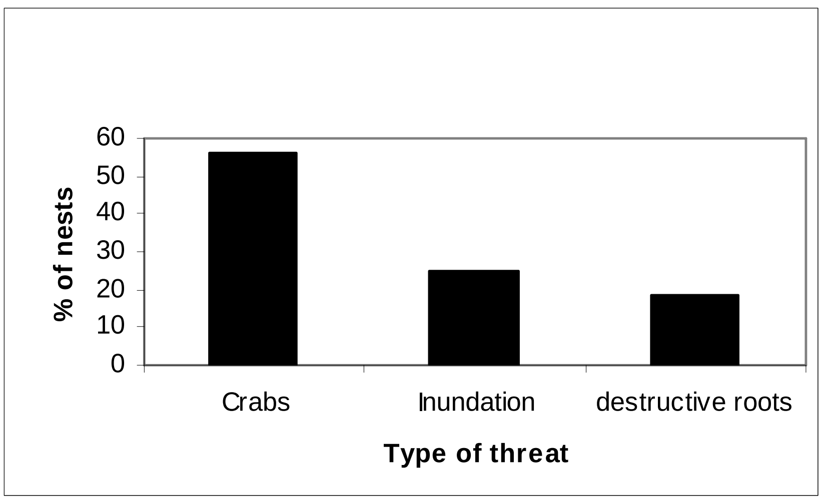

Figure 6.10 - Cause of destruction of the unhatched in-situ nests - % of nests destroyed

The hatching success of the monitored nests that did produce hatchlings was 67.0% (n=19). The additional nests that were excavated on the beach had a hatching success of **68.7%** (n=95). There was no significant difference between the hatching success of the monitored nests and the other randomly excavated nests ($U_{95,17}$ = 789, N.S. (Mann Whitney U)).

Hatchery nests

A total of 15 nests were translocated into the hatchery. The nest profile for each is shown in figure 6.11.

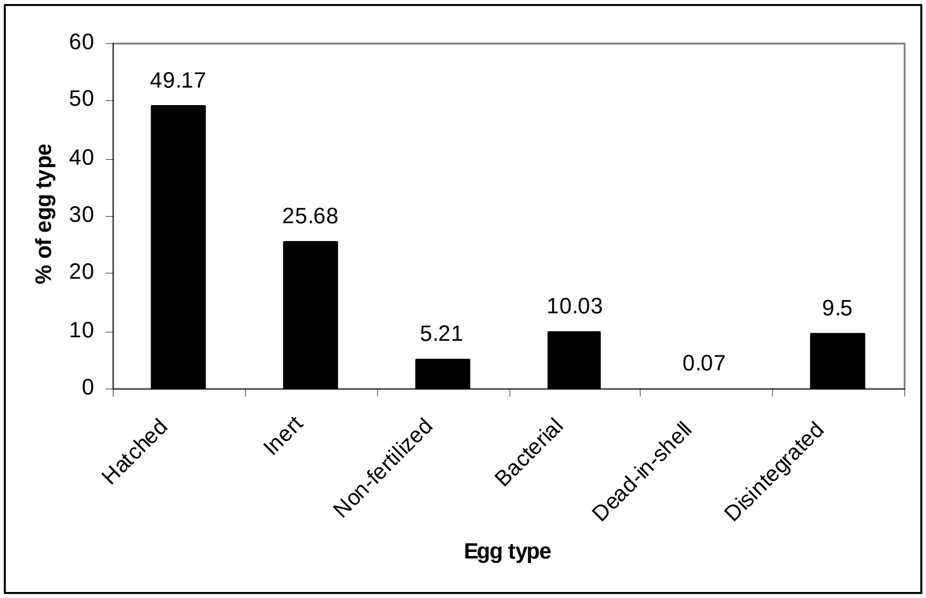

Figure 6.11 - The percentage of each type of egg in hatchery leatherback nests

The total mean number of viable eggs was 74.7 (*n*=15, *SD=15.6*) (total eggs – inert eggs) and the mean number of inerts was 25.9 (*n*=26, *SD=11.7*).

The mean depth to the top of the nest chamber was 53.8cm (*n*=15, *SD* =5.6) and the mean depth to the bottom of the nest was 68.2cm (*n*=15, *SD*=5.8).

The mean temperature inside the hatchery nests was 29.6ºC (*n*=15, *SD*=0.31) and the average incubation period was 63.1 days (*n*=15, *SD*=2.21).

Out if the 15 nests that were translocated into the hatchery, all of the nests produced at least one hatchling. The nests success was **100%.** There was no predation by any animal or insect in the hatchery nests. The mean hatching success of the hatchery nests was **68.8%.**

Comparison with in-situ nests and hatchery nests

The egg profiles for the hatchery nests and the in-situ nests were found to be similar. The only significant differences found were between the numbers of dead-in-shells and the number of disintegrated eggs (table 6.1) ($U_{15,95}$ = 363, p<0.001 and $U_{15,95}$ = 436.5, p<0.013 respectively).

Table 6.1 – Results of the Mann-Whitney U tests to compare the means of the nest profiles for the hatchery and in-situ nests.

	Hatched	Inert	Non-fert	Bacterial	DIS	Disint.
Mann-Whitney U	**578.0**	**550.5**	**664.5**	**551.0**	**363.0**	**436.5**
Wilcoxon W	**5138.0**	**670.5**	**5224.5**	**671.0**	**483.0**	**4996.5**
Z	**-1.172**	**-1.412**	**-.426**	**-1.4**	**-3.3**	**-2.4**
Asymp. Sig. (2-tailed)	**.241**	**.158**	**.670**	**.158**	**.001**	**.013**

The depths of the hatchery nests and in-situ nests were significantly different from each other (using the bottom depths of the nests) ($U_{15,95}$ = 76.5, p<0.001 (Mann Whitney U).

The mean number of inert eggs found in the two different groups of nests were not significantly different from each other ($U_{15,95}$ = 550.5, N.S. (Mann Whitney U). The number of viable eggs in the hatchery nests and the in-situ nests were significantly different from each other ($U_{15,95}$ = 483.5, p<0.046 (Mann Whitney U).

The nest success was significantly different in the in-situ nests and the hatchery nests. There was no significant difference between the hatching success in the hatchery nests and the in-situ nests ($U_{15,17}$ = 126, N.S. (Mann Whitney U).

The temperatures in the in-situ and the hatchery nests were significantly different ($U_{11,15}$ = 10 $p<0.001$ (Mann Whitney U)), as were the incubation periods ($U_{12,15}$ = 22.5, $p<0.001$ (Mann Whitney U)).

Temperature and incubation period

Using the hatched nests from both the in-situ nests and the hatchery nests, the mean nest temperatures were correlated with each other to test for a relationship. These two variables were negatively correlated with each other (r = 0.75, $F_{1, 23}$ = 30.1, $p<0.001$) (figure 6.12), showing that the incubation duration gets shorter as the temperature increases.

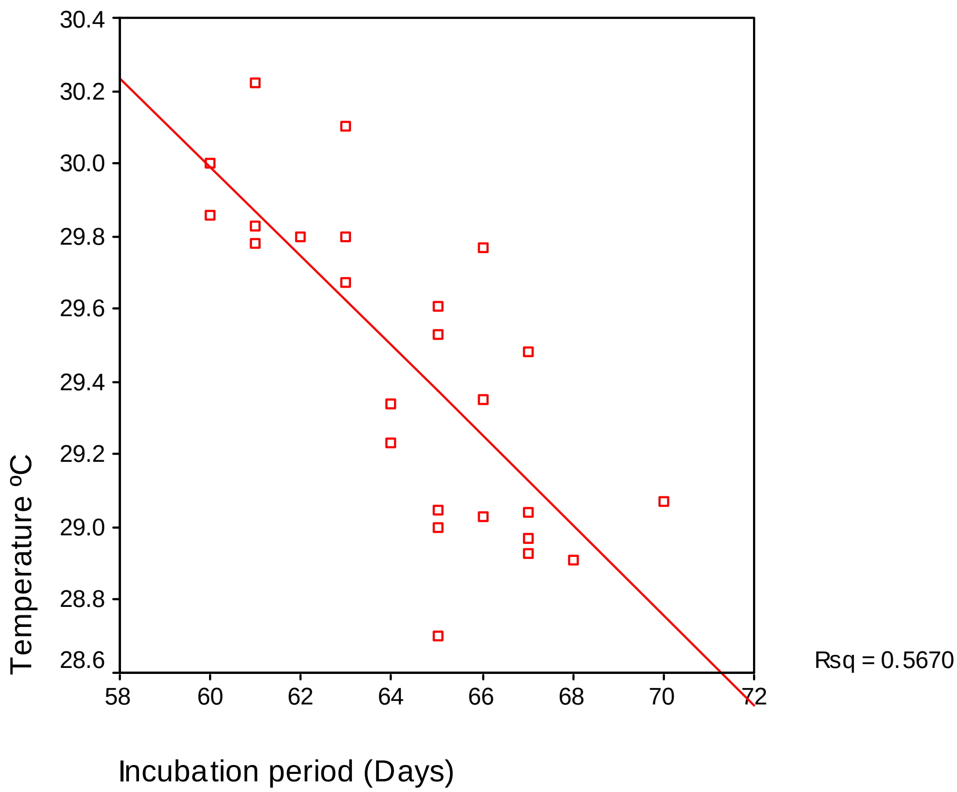

Figure 6.12 - Scatter plot showing the relationship between mean nest temperature and the incubation period

6.5 Discussion

In-situ nests

The nest profile from the excavated in-situ nests shows that approximately half of the eggs are hatched and a third are inert eggs. Hall (1990) also found that 30 % of the total clutch size of leatherback nests was made up of inert eggs. Approximately 10 % of the eggs were infected by bacteria and showed no signs of embryo. Only a small percentage were found to be un-fertilized, dead-in shell and disintegrated. The mean number of viable eggs in the in-situ nests was 65.9. This is perhaps at the lower end of the range of viable egg numbers found in other leatherback populations; an average of 65 – 80 eggs (Bell et al., 2003); 86 eggs at Tortuguero, Costa Rica (Leslie et al., 1996); 83.1 eggs at Florida beach (Maharaj, 2004).

The mean depth of the of the in-situ leatherback nests was 90 cm to the bottom and 73 cm to the top of the nest chamber. These depths are normal for leatherback nests (Livingstone, 2006). The nests were found to be deeper at the time of excavation then they had been at the time of laying. It is thought that this is due to sand build up on the beach over the nesting season, causing the nests to be deeper at the end of the incubation period.

The temperatures on marine turtle nesting beaches are typically between 24 and 33 °C (Ewert, 1979). Temperature-dependent sex determination (TSD) operates to produce male hatchlings at lower temperatures and females at higher temperatures. The pivotal temperature is the temperature at which the sex ratio is 1:1, and varies between 28 to 30 ºC, depending on species and population. The sensitive period for sex determination occurs in the middle third of incubation (Yntema and Mrosovsky, 1982; Mrosovsky, 1994). The pivotal temperature for leatherbacks in the Atlantic is 29.5 °C (Rimblot et al., 1985; Rimblot-Baly et al., 1987). The mean temperature in the leatherback nests on the beach at Gamba was 29.07 °C. Based on this figure, it is likely that the nests laid on the Gamba study beach mostly produce male hatchlings. However, this needs to be investigated in more detail since the overall mean temperatures are based on substantial variability close to the pivotal temperature.

The mean incubation duration in the in-situ nests was 67 days. Nest temperature had a significant negative relationship with the incubation duration (figure 6.12), as found in other studies (Mrosovsky et al., 1984; Miller, 1985; Marcovaldi et al., 1997; Booth and Astill, 2001). As the nest temperature increases, the incubation period decreases.

The hatching success of individual marine turtle nests is typically high (80 % or more) unless disturbed by external factors such as predation, microbial infection and inundation (Whitmore and Dutton, 1985). The hatching success of leatherback nests has been shown to vary between locations, seasons and individuals (Bell et al., 2003), although researchers generally agree that hatching success is significantly lower for leatherbacks than for other turtle species (Whitmore and Dutton, 1985; Bell et al., 2003; Girondot et al., 1990). Bell et al. (2003) investigated the reasons for lower hatching success in leatherback nests, and concluded that it was due to high hatchling mortality rather than infertility. This was also found to be the case in this study. Lower hatching success may also be due to the higher incidence of inundation as leatherbacks tend to lay their nests closer to the high water mark than other species (Whitmore and Dutton, 1985).

The results show that approximately half of the leatherback nests laid on the study beach in Gamba hatch successfully (54%), while the other half are fatally affected by various events (46%). The reasons for the nests not hatching were due to three major threats. Crab predation affected the largest proportion of nests, sometimes completely destroying a nest so that nothing remained (56%) (figure 6.13).

Figure 6.13 – Leatherback nest predated by crabs

Crabs also predated upon nests that did produce hatchlings, although it is suspected that the hatching success was reduced. 25% of the unhatched nests were affected by inundation by the sea and the 19% by invading roots (figure 6.14). Both of these threats are dependent on where on the beach the nest is positioned in relation to the high water mark and the backing vegetation. All the threats present on the beach were natural, with little human interference.

Figure 6.14 – Leatherback laying her eggs in the backing vegetation

Compared to other regions and populations, the hatching success on the study beach at Gamba is relatively high (68.7%); 64% in the US Virgin Islands (Eckert and Eckert, 1990); 64.1% in Malaysia (Eckert and Eckert, 1996); 73.3 % Trinidad (Livingstone, 2006); 21 % Costa Rica (Bell et al., 2003); 33.5 % in Central and South Brevard County, Florida (Maharaj, 2004), 48.6 % on Playa Grande, Costa Rica (Williams, 1996); 53.2 % in St Croix (Eckert and Eckert, 1985); 72.2 % in Culebra, Puerto Rico (Tucker and Frazer, 1991); 35 % in French Guiana and Suriname (Maros et al., 2003; Girondot et al., 2005).

Hatchery and in-situ comparisons

The nest profiles for the hatchery nests were very similar to that in the in-situ nests. The only significant differences were the number of dead-in-shells and in the number of disintegrated eggs. The number of dead-in-shells in the hatchery was lower, and the number of disintegrated was higher. A possible reason for this may be due to the fact that the sand at the bottom of the hatchery was very dark and dirty looking, and possibly contained more bacteria that would break down larger embryos faster, making them disintegrated rather than finding them as whole dead-in-shells. It is recommended that, if the hatchery is to be used in the future, that it is dug deeper and filled with clean sand from the beach so that the eggs are not affected by the original sand at the back of the beach where the hatchery is located. It is also recommended that the sand is changed every two years to keep it as fresh and clean as possible. This way the hatching success for the translocated nests can be maximized.

The number of viable eggs in the nests in the hatchery was significantly more than in the in-situ nests. It is thought that this is due to the fact that many of the in-situ nests had been attacked by crabs, and therefore some of the eggs had been removed or totally destroyed, making the number of viable eggs appear less than what was originally laid. There was no significant different between the number of inert eggs in each group of nests. The depth of the nests in the hatchery was significantly shallower than in the in-situ nests. The nests in the hatchery were placed at a mean depth of 70 cm, as this was the average depth of the in-situ nests when they were laid. This again highlights the build up of sand on the beach.

There was a significant different in nest temperatures in the hatchery and in the in-situ nests, with the hatchery nests having a higher temperature. This is possibly to do with the nests being shallower allowing more of the ambient air temperature to affect the nest. In turn, the incubation period was also significantly shorter that in the in-situ nests.

In contrast to the nest success of the monitored in-situ nests, 100% of the nests in the hatchery produced at least one hatchling. This highlights that the hatchery is very effective at keep out predators and keeping the nests safe from the other threats present on the beach. The hatching success measured from the in-situ nests was not significantly different from the nests in the hatchery. This is a very positive result, demonstrating that the hatchery can be a very effective approach to conservation and increasing hatchling production.

Hatchery assessment

The results presented here are different from the results of the study in 2004/2005, where the hatching success in the in-situ nests was double that of in the hatchery. The hatching success from the 2004/2005 field season was also higher than in this study (83% compared with 67%). However this may be due to a smaller sample size, and a bias towards digging up nests that had a higher number of hatchlings tracks leading from them, making them easier to identify (Verhage and Moundjim, 2005). The much larger sample size in this study, and the fact that the hatching success in the closely monitored nests was not significantly different to that of the randomly identified nests, shows that the hatching success in this study is a more realistic figure.

It was suggested that the low hatching success in the hatchery in 2004/2005 was possibly due to differing temperatures on the beach and in the hatchery, or translocation technique. The temperature in the nests was found to be significantly different in the in-situ nests and the hatchery nests. However, there was no significant difference between the hatching success. This suggests that temperature was not the cause of the differing hatching success rates in the 2004/2005 study.

We also used a different translocation technique to move the nests to the hatchery in 2005/2006. The technique used was much less intrusive and involved much less direct handling of the eggs. We feel that this new technique is the reason for the improved hatching success in the hatchery. The local group were trained in this technique are will be able to use it in future years. Although the differing nest temperatures did not appear to affect the hatching success, it most likely had an affect on the sex ratio of the hatchlings produced. This should be taken into consideration for the hatchery if it is continued in future years.

The hatchery has proved to be very successful in terms of protecting nests and hatchlings, and is much improved from last year. At present the hatchery is on a small scale, able to hold 20 nests. The conservation benefits of this are, of course positive, however to have an impact on the population, it would have to be done on a much larger scale. It is important to maximize hatching success and increase the number of hatchlings that reach the seas (Bell et al., 2003). To do this, hatcheries have been put in practice in a number of places where the mean hatching success is particularly low (Girondot et al., 1990; Mortimer, 1999; Van de Merwe et al., 2005). However, in comparison to other leatherback populations, the nest success and hatching success on the Gamba beach is relatively high, and all the threats are natural. Therefore a full scale hatchery is perhaps not required at this time at Gamba considering the large amount of time, effort and manpower it takes to fill and monitor the hatchery. However, the hatchery also proved to be successful in attracting tourists, and also was used for the education and awareness of local school children by the local NGO Ibonga (figure 6.15).

Figure 6.15 – School group at the hatchery on Gamba beach

Using the new translocation techniques, the hatchery has proved to be a good conservation measure, and not in any way detrimental to the moved leatherback eggs. With this in mind, the small-scale hatchery as it is now is worth continuing for the education benefits alone. Also, the hatchery could be enlarged if the need for more conservation is identified by future decreases in the nesting female population. The hatchery in Gamba can also be used as a model for other leatherback nesting areas in Gabon.

6.6 Conclusions and recommendations

The main outcome of this study is a baseline of data on several aspects of the ecology of leatherback nests on Gamba beach, Gabon. With this knowledge, threats to natural nests can be identified and reduced, and improvements can be made to the open air hatchery, increasing hatching success on translocated nests. This, in turn can increase the hatchling output, including nests which may ordinarily have been destroyed by crabs, inundation or invading roots.

The training of the local counterparts will ensure effective and analogous data collection into the future, so that changes in nest ecology can be identified, and improvements in the hatchery put into practice. It is recommended that the methodology for assessing nest success and hatching success used here be employed by the other marine turtle monitoring projects in Gabon so that comparisons can be made in differing nesting areas, and so the data can be combined and analyzed nationally, to compare with other large leatherback rookeries worldwide.

The hatchery will remain as a successful educational tool for tourists and local schools, generating much needed funds, and helping to raise awareness.

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