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THE CRAB *Polybius henslowii* (DECAPODA: BRACHYURA) AS A MAIN RESOURCE IN THE LOGGERHEAD TURTLE (*Caretta caretta*) DIET FROM NORTH AFRICA

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ABSTRACT

Marine turtles are known for feeding on a great variety of preys... from the soft jellyfishes to the hard shells. However, this does not mean that every turtle in fact eat this wide variety of preys throughout its life, but depending on the habitat and age they show certain preferences, making this selection based on the abundance (quantity), the nutritive properties of the prey (quality) and how easy is to get (accessibility). In this paper we present the almost exclusive diet of the Loggerhead turtle Caretta caretta (Linnaeus, 1758) thanks to 5 years of intensive research on either dead and alive specimens at the North African coasts of Ceuta (Spain), Morocco and Western Sahara. We find out the real importance of the crab Polybius henslowii (Leach, 1820) in Caretta caretta diet, discussing some aspects of this marine turtle as a specific rather than a generalist feeder.

Key words: *Caretta caretta,* feeding ecology, *Polybius henslowii*, North Africa.

RESUMEN

Es conocido que las tortugas marinas se alimentan de una gran variedad de presas..., desde las blandas medusas hasta las duras conchas. Sin embargo, esto no significa que cada tortuga tenga en su dieta esta gran variedad de alimento a lo largo de su vida, sino que, dependiendo del hábitat y de la edad, muestran ciertas preferencias, realizando esta elección en función de la abundancia de la presa, de sus propiedades nutritivas y de la facilidad para conseguirla. En este artículo presentamos la dieta de la tortuga boba *Caretta caretta* (Linnaeus, 1758) con datos de 5 años de investigación intensiva con ejemplares vivos y muertos de la costa norte africana de Ceuta, Marruecos y Sahara Occidental. Descubrimos la importancia del cangrejo *Polybius henslowii* (Leach, 1820) en la dieta de *Caretta caretta*, aportando pruebas para creer que esta especie es, en cuanto a su alimentación se refiere, más específica que generalista.

Palabras clave: *Caretta caretta,* ecología alimentaria, *Polybius henslowii*, Norte de África.

1. INTRODUCTION

It is well known that the loggerhead turtle, —although primarily carnivorous—, may feed on many different preys (see DODD, 1988 [9]; VAN NIEROP & DEN HARTOG, 1984 [30]). We offer new data on the feeding ecology of the Loggerhead turtle in neritic habitat of shallow waters and sheltered bays in the African shore of the Strait of Gibraltar.

In 1817, the Reverend John Steven Henslow, Professor of Botany in Cambridge and Charles Darwin's teacher (he persuaded his disciple to join the "Beagle" expedition) found the crab *Polybius henslowii* (fig. 1) in a herring net in north Devon and sent the specimen to Leach, who described it. Nowadays, there are still some aspects of this crab biology, as the concentrations (blooms) and the reproduction pathways, that still remain unknown (GONZÁLEZ-GURRIARÁN *et al.*, 1993 [16]), although those authors have remarked the importance of this species as a seasonal resource in Galicia, on the Northwest corner of the Iberian peninsula.

According to the literature, the species has been recorded from the North Sea to the Canary Islands, including Western Mediterranean (ZARIQUIEY ÁLVAREZ, 1968 [31]; MANNING & HOLTHUIS, 1981 [20]). Furthermore, *P. henslowii* is able to constitute large pelagic concentrations in order to reproduce themselves (GONZÁLEZ-GURRIARÁN, 1987 [14]; GONZÁLEZ-GURRIARÁN *et al.*, 1991 [15]; GONZÁLEZ PÉREZ, 1995 [17]). GONZÁLEZ PÉREZ (1995) [17] has recorded those crabs forming concentrations of thousands of specimens in February, off Lanzarote coast (Canary Islands), and Dr. Peter Wirtz (pers. com.) has recorded this crab sporadically from Azores and never forming concentrations. We have observed many crabs remains in the food of some sea birds in the islets located at the North of Lanzarote (winter 1997) (A. Brito, pers. obs.).

2. MATERIAL AND METHODS

Ceuta is located in North Africa, in the South shore of the Strait of Gibraltar (fig. 2), with double influence, Mediterranean and Atlantic, and complex winds and sea current patterns. There are noticeable records of sea turtle exploitation by ancient civilizations that were established at this strategic land (CASASOLA & PEREZ, 1999 [6]; GARCÍA DE LOS RIOS *et al.*, 2003 [13]).

Although our research is being performed along the Ceuta region (Cape Negro to Beliones Bay, about 100km. long) —fig. 2— we also have stored some data from other areas along the Moroccan Atlantic littoral, where the crab is also present (De los Ríos *et al.*, in prep.). In addition, we offer news about other *P. henslowii* predators through almost 3000 km. of coast, remarking the importance of this crab as an important resource in the regional context of North Africa.

The present study is based on the investigation of more than 150 Loggerhead turtles stranded at Ceuta region performed during the years 1998-2004 with the examination of the gut content from the year 2000 on. Sporadically, we had the chance to perform necropsy on turtles also coming from the Atlantic and the Mediterranean coast of Morocco.

Measurements and necropsy techniques were made following the Septem Nostra (Association for the Study, Protection and Diffusion of the Natural and Historic Heritage) protocols (see OCAÑA & DE LOS RÍOS, 2002 [25]). The main biometry data were: SCL (Straight carapace length) TL (Total length) SCW (Straight carapace with)

At sea, the turtles were hand captured and sporadically intubated to pump their stomachs out, in order to obtain food samples. For those ill animals under rehabilitation in the tanks, we just have to wait for excrement to check out what they ate the previous days.

During the ruled necropsies, to find out the cause of death, the turtle are opened, cutting through the carapace-plastron cartilaginous bridges, axilar and pelvic skin, and removing the plastron from the appendicular attachments and then the whole celomic cavity is exposed. Later, the intestinal tract is opened and the content stored for further analysis. Once the content is removed, we obtain the dry weight and examine the sample under the binocular dissecting microscope; the final result is stored afterwards in alcohol 70%.

Some commercial fish from the boats operating along Morocco (Mainly at El Rincón, Larache, Tanger, Asilah and Agadir), was checked on a daily basis at the Spanish border in the search for the crab presence (to help us to increase the knowledge about the biology of this unknown specie) and the analysis of the stomach of other potential predators of the crab (De los Ríos *et al.*, in prep.). Besides, sporadic direct observations of fishermen working at the Harbour of El Rincón were made.

In order to detect the presence of the crabs in our sea shores as well as stranded specimens of *C. caretta,* we were supported by a stranding network that search along our littoral. Nowadays, such net involves a professional multidisciplinary team and more than 60 volunteers. Thanks to a project focussed on Ceuta marine tetrapods (DE STEPHANIS *et al.*, 2001 [8]) we had the opportunity of searching our littoral widely throughout during the four seasons of the year, from boats looking for sea turtles and its main prey, by making transects covering the whole studied area (see DE STEPHANIS *et al.*, 2001 [8] for methodology).

3. RESULTS

According to fig. 3, in our littoral (From Ceuta to Cape Negro), immature, juvenile, sub adults and adults turtles are, from individuals recently recruited to neritic habitats measuring 34 cm. SCL to adults measuring 100 cm. SCL, but as we can see in the graphic, the sub adult population is predominant present (Size range. n= 167; Mean: 67,2574; SD: 11,1550; Median: 68; Mode: 70; Minimum: 34; Maximum: 100. Measures: SCL).

At the same time, the crabs have been observed forming big concentrations (blooms) from May to August stranded at the beaches (fig. 5), for reasons that we still ignore, but that may have to do with the reproduction cycle (GONZÁLEZ-GURRIARÁN, 1987 [14]; GONZÁLEZ-GURRIARÁN *et al.,* 1991 [15]). In addition to this, during the observations on board, the turtles have been seen regularly eating these crabs.

Investigations about the biology of the crab reveal similar concentrations which take place around March and April at the Atlantic Coast of Morocco, from the South Sahara (Laâyoune) to the north (Asilah —fig. 2—) and the Mediterranean as well. Sometimes in the South coast of Morocco, there are so many crabs that they become a problem for the fishermen nets (personal observations).

As a consequence of the veterinary inspection that take place in the Spanish border (see material and methods), specimens of *P.henslowii* were noticed all year round in the fish boxes, mainly of *Pagrus spp.*, where we found the highest biomass of crabs, giving an idea on the type of habitat and seasonal presence of this marine invertebrate at these latitudes.

As we can see in fig. 4 (which represents monthly the mean of the years 2000-2004), turtles are present all year long. After checking the gut contents of our turtle specimens, we notice the presence of *P.henslowii* during all seasons, being in Spring and in Summer (with a peak in July) when the biggest number of turtles stranded which, at the same time, showed the crab inside their stomachs as a main gut contents (90% or 100% of the content is *P.henslowii).*

We have reviewed the feeding ecology papers on similar behaviours of Loggerhead turtle and other marine turtles in different world areas. According to our review and the one made by Mortimer (see Table one), *C. caretta* is able to feed on single but abundant and easy catching preys. Indeed, the preys are changing from one region to others, but in all the regions analyzed the behaviours of feeding on certain preys confirm our hypothesis that *C. caretta* populations exploit specific marine resources all over the world. This assertion is consistent with our current data and also with the data presented in this paper (Table 1). Also, for other species of sea turtles, we review similar feeding patterns (Table 2).

In our geographical area, we have also observed crabs in the drop pills of the sea Gull (*Larus argentatus*) and inside the stomach of several fishes as *Pagrus spp.*, Tuna (*Thunnus thynnus*), *Dicentrarchus spp.*, *Dentex dentex*, *Sparus aurata, Pagellus bogavareo* (De los Ríos *et al.*, in prep.) and *Alepisaurus ferox* (see GONZÁLEZ PÉREZ, 1995).

The main cause of death of these turtles (almost 100%) is the interaction with fisheries, specially nets, been the most common, drifting nets and Almadrabas (an ancient art whose main prey is the tuna fish, consisting of a labyrinth of nets through where the fish is orientated until it gets to a final pool where it is kept alive until is lifted).

4. DISCUSSION

4.1. *The regional resource importance*

The most important crab-watching in our region, coincident with the abundance of marine turtles, is during spring and summer, when we find the stomachs of *C. caretta* full with crabs (99-100% of the whole content). But the occurrence of crabs in the gut content of some specimens of *C. caretta* stranded on January proves its presence as a food resource all year long, further away than a seasonal happening.

The fact that these stranded turtles may have been drifted away from some other area, enforce the idea of a true regional phenomenon. Nevertheless, many corpses are directly rescued from the nets, so it can be certainly affirmed that those turtles belonged to the area.

It is obvious that the process of up-welling serves as a powerful enrichment of the sea water surface, and a well known consequence of this phenomenon is the high marine plankton production. According to GONZÁLEZ-GURRIARÁN (1987 [14]), the presence of concentrations of this crab may be considered related to enrich areas affected by up-welling. Along the Atlantic coast of Morocco there are a very strong up-welling influences (ORBI *et al.*, 1998 [26]); our region is strongly influenced from the general up-welling process of Alboran Sea (see ESTRADA *et al.*, in MARGALEF, 1989 [10]) but also, in Ceuta, there is a local up-welling having its epicentre at Punta Almina. (BALLESTER & ZAVATTI, 1983 [1]). The occurrence of jellyfishes blooms in this area (OCAÑA & DE LOS RÍOS, 2003 [24]) may be also linked with the high production that takes place in the area, and this fact is consistent with the seasonal presence of *Dermochelys coriacea* in our littoral (OCAÑA & DE LOS RÍOS , 2003 [24] ; De los Ríos & Ocaña, in prep.). This kind of occur-

rence is not isolated, but have been described someplace else, like in West Florida Shelf, Gulf of Mexico, where large Loggerhead turtles were found associated with two submarine geothermal springs (BJORNDAL, 1997 [3]).

Furthermore, in the Strait of Gibraltar the fishermen use them as bait, keeping high quantities of crabs on shallow waters in sheltered bays (personal observations). In the coast of Portugal, during summer, this crab is even commercialized in some local markets (COSTA *et al.*, 2003 [7]). Other industrial uses are found North-west Spain, in Galicia, where many years ago they were used as fertilizer (see GONZÁLEZ-GURRIARÁN, 1987 [14]). Nowadays, there is a project to obtain industrial application in aquaculture out of this crab (IGLESIAS *et al.*, 2000 [19]).

Although very little is known about the occurrence and abundance of this crab along the Atlantic Moroccan coast, we confirm it forms large pelagic concentrations from Larache to Laâyoune in spring and summer, been even a big problem for the shore fishermen.

In the region of Alhoceima (an important harbour fishery in the Mediterranean coast of Morocco, 150 km. from the Spanish town of Melilla), the crab has been also recorded in high quantities (Dr. Tudela, personal communication —De los Rios *et al.*, in prep.—).

What happens during the year along the coast of Morocco is something that remains unknown. However, the remarkable occurrence of the crab in the stomachs of a number of other marine vertebrate reveals the importance of *P.henslowii* in the context of the whole marine ecosystem in this part of the world (De los Ríos *et al.*, in prep.).

All these data support the idea of the importance of protecting such a key resource from any kind of decreasing factor which may act against the equilibrium of the marine ecosystem.

4.2. *About the relation between the crab and the turtle*

The discovery of this crab as a main gut content of *C. caretta* in this part of the world is a remarkable fact that has remained unknown until now. Although there are certain number of papers on the diet of *C. caretta* (see DODD, 1988 [9]), the presence of this crab in the loggerhead turtle has never been reported. However, attending to the crab distribution and concentrations, which is a well known phenomenon from North Sea to Canary Islands (see GONZÁLEZ PÉREZ, 1995 [17]) including Alboran sea, the lack of data of the relation among this crab and this turtle could be due to the absence of post-mortem studies, furthermore the crabs could have been overlooked, remaining in the gut content or revealed on papers as unidentified crabs!. The prevalence of *P. henslowii* in the gut content of our *C. caretta* populations sets up its importance as a main resource for this species along several months, so during these periods turtles can stock fat reserves. We realize the close relation between both, the turtle and the crab, along the year. However, we also noticed other preys (especially gelatinous plankton) (Table 1) during those months when the percentage of crabs in the stomachs of the remaining turtles is low. Apparently, this seasonal adaptation occurs anytime the main prey is not sufficiently present for whatever reason in the area. According to this, in South Texas waters, and during the spring, the sea pen (*Virgularia presbytes*) is the food of election for the Loggerhead turtles, while the crabs are eaten during summer and fall when they increase in number (BJORNDAL, 1997 [3]).

C. caretta and *P. henslowii* perform a clear case of trophyc relationship between prey and predator being the abundance, the nutritive value and easy accessibility of this resource by *C. caretta* the keys to understand the phenomenon.

4.3. *Generalist versus specialist*

The Loggerhead turtle belong to a reduced group of marine turtles that inhabit the seas from many millions of years ago (PRITCHARD, 1997 [28]; BOWEN, 2003 [5]; GULKO & ECKERT, 2003 [18]). So it is a plausibly option that loggerhead turtles knows how to get food by searching for some resources able to support their vital requirements.

The data offered in the Table 1 shows there are abundant regional resources which *Caretta caretta* is able to feed on along the different littorals of the world.

Ours is not the first finding of a prevalent food resource in Loggerhead turtle (Table 1), not even in the other marine turtles, especially *Dermochelys coriacea (*Table 2). This aspect combined with some behaviour like the "in faunal mining" (see BJORNDAL, 1997 [3]; FRICK *et al*., 2001 [11]), indicates an active search with a previous idea of what is wanted or what the turtle "feels like eating".

In our region, loggerhead turtles are eating one resource remarkably: After all, the crab is a nutritive food (GONZÁLEZ-GURRIARÁN, 1987 [14]) being easily caught by this turtle at a low energetic cost due to its abundance, and the fact that *P. henslowii* spends most of its time in the water column flouting with the currents.

In a general context, we have searched for bibliographic information and offer some data of specialist feeding behaviour in other world coasts. There are not convincing evidences that *Caretta caretta* is a feeding specialist all over the world but indeed there are enough scientific evidences to think about avoiding the topic about the passive incidental finding or the generalist loggerhead capability to feed on almost any marine creature that, on the other hand, no author talks about clearly. Unfortunately, there are not papers about feeding ecology or ecology of sea turtles in a wide sense (whatever pelagic or littoral habitats) that allow us understand this phenomenon properly. Most of them are a simple list of items found in the stomach, without a further analysis of the turtle and its environment in an ecological context.

The specialization feeding pattern, presented in the current paper proves that a new concept of integrated biological studies on sea turtles is necessary in order to increase our knowledge about the ecological relation between sea turtles and the marine ecosystem.

So far, to conclude a loggerhead feeding ecology model, we need to search for new information in order to make possible understanding the regional feeding ecology of loggerhead turtles around the world.

Loggerhead turtles can be also opportunistic (TOMÁS *et al*., 2003 [29]), although this is a very recent artificial phenomenon located in areas with fishery activities.

5. CONCLUSIONS

1) *P. henslowii* is the main resource for *C. caretta* in the Ceuta region (Ceuta-Cabo Negro-see map). According to the system of currents, some corps may come from Atlantic North Africa, Alboran Sea or Southern Europe. Moreover, the fact that we recorded concentrations of *P. henslowii* along the Atlantic and the Mediterranean coast of Morocco, from Sahara coast to Al Hoceima (see map), remarks that is a regional phenomenon.
2) The Loggerhead turtle feeds on this crab along the year, although May and September are when the turtles present the highest quantity of crabs in its gut content.
3) Our research sets up that *C. caretta* presents a very specific diet in North Africa, opposite to the generalist perspective on this species.

4) The species *P. henslowii* is a resource not only for *C. caretta* but for a number of marine species including birds and also pelagic and benthopelagic fishes.
5) Due to the close relation between predator and prey they should be protected at the same extent at their habitats to prevent a disaster of lost of biodiversity.
6) Integral studies (with multidisciplinary teams) in order to understand the ecological relations between the marine turtles and the ecosystem as a whole are needed. Studies of regional ecology are important for this purpose.

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AUTHORS	PREY	ABUNDANCE	PLACE	OTHER PREYS	COMMENTS
Fowler, 1914	Hermit crab (*Pagurus pollicaris*) and borers (*Matica duplicata*)	100%	Off New Jersey		
Hughes, 1974	Molluscs (*Bufonaria crumenoides* and *Ficus subintermedius*)	Predomination	Off natal coasts	Fishes and even hatchling loggerheads	Females In Mortimer
Limpus, 1973	Prawns and fish repons	Predominantly	Queensland		Nesting season In Mortimer
Limpus, 1978	Shells Cerithidae, *Haliotus* and *Turbo*	Mostly eaten	Great Barrier Reef	Jellyfish	In Mortimer
Mary Medoza	Horseshoe crab (*Limulus polyphemus*)	95%	Moskitoo lagoon, Brevard County, FL.	Blue crab (*Callinectes*) and mullet	Sub-adult and adult turtles In Mortimer
Bjorndal, 1997	Sea Pen (*Virgularia presbytes*)	59%	South Texas	Crabs	Seasonal incidence In Lutz and Musick
Bentivegna, 2003	Seahorse	69,2%	Gulf of Naples		Portunid as a second prey
Nichols *et al.*, 2000; Peckham & Nichols, 2003	Red crab (*Pleuroncodes planipes*)	100%	Baja California		Pelagic crab (*Planes cyaneus*), *Velella velella*, *Lepas* also found in CP
Ocaña & de los Ríos, 2002	*P. henslowii*	99%	W.N. Africa	Jasis zonaria	Tunids, saparids and larids as other predators

Table 1. Examples of predominant preys in *Caretta caretta*.

AUTHORS	SPECIE	PREY	ABUNDANCE	PLACE	OTHER PREYS	COMMENTS
Brogersma, 1969	*Dermochelys*	Jellyfish	100%	Atlantic		
Waller, 1964	*L. olivacea*	Red crab (*Pleuroncodes planipes*)	100%	Mexico?		
Mortimer updated	*Chelonia mydas*	*Thalassa testudinum*	85%	Nicaragua	Seagrass, and algae	In Mortimer
Hilderbrand	*L. kempii*	Portunids (*Callinectes and Ovalipes*)	primarily			
Dodd, 1988	*L. kempii*	Portunid Blue Crab (*Callinectes sapidus*)	Primary	Chesapeake bay (West Virginia)		In press
Dereh Green	Ridley	crabs	100%	Ecuador		Den Hartog, com. in litt.
Anne Meylan, 1988	*E. imbricata*	sponges	94,2%	Caribbean Coral Reef		

Table 2. Examples of predominant preys in other marine turtles.

Figure 1. The potunid crab *Polybius henslowii*.

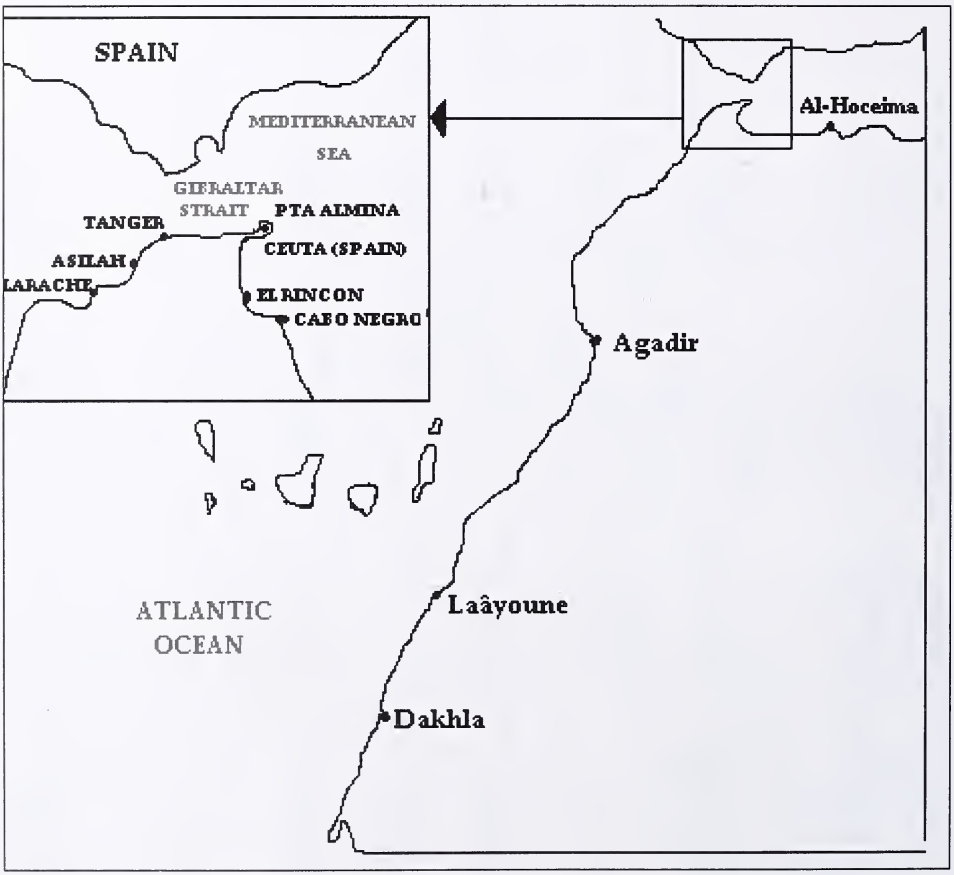

Figure 2. Map.

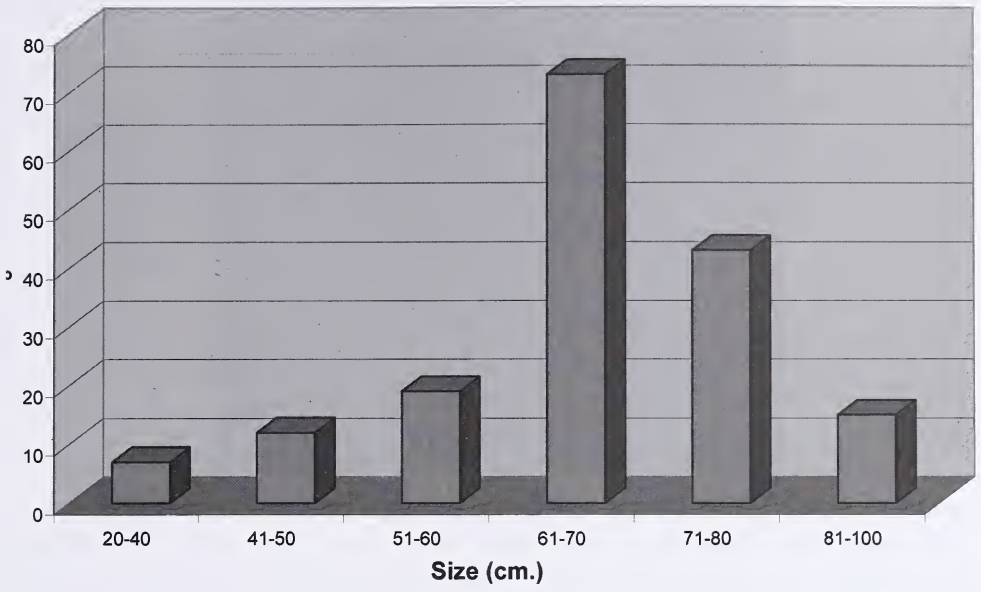

Figure 3. Turtle sizes.

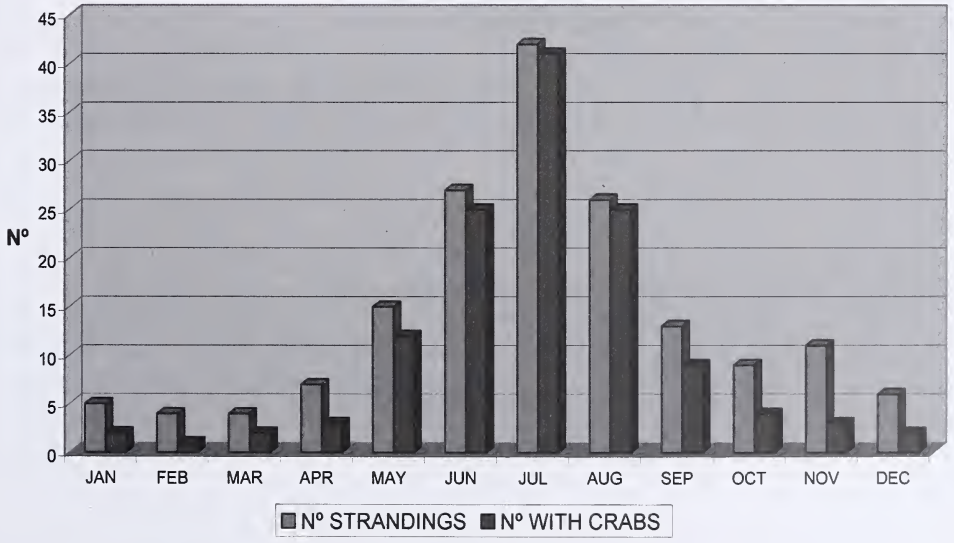

Figure 4. Monthly compared graph among turtles atranded and turtles with crabs (2000-2004).

Figure 5. *Polybius henslowii bloom.*