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- universities and NGOs, and public research bodies
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Its mission:

To halt and reverse the destruction and degradation of Mediterranean wetlands and their natural resources, and promote their wise use.

The Station's programmes are managed by multidisciplinary teams.

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Chick diet composition of Lesser Crested Tern *Sterna bengalensis emigrata* at their Mediterranean breeding sites in Libya

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ABSTRACT

The chick diet of the Mediterranean population of Lesser Crested Tern *Sterna bengalensis emigrata* was investigated in 2008-2010 and 2012 at three breeding sites on the Libyan coast, Gara Island, Julyanah islet and Al Ulbah Island, where over 2,400 pairs of Lesser Crested Tern breed every summer. The main objectives were to document prey species delivered to chicks, and the inter-site differences in diet structure in terms of prey species, diversity and biomass. Regurgitated prey samples with prey specimens left at colony sites are included in the present study. Samples were collected by hand during field visits to colonies (discarded prey specimens found on the ground) and during chick banding (when handled chicks regurgitate recent food).

A total of 422 diet samples belonging to 18 families of fish and one family of cephalopods were collected during the study period. Adult terns fed their chicks with different prey species at each site, indicating an adaptation in foraging yield at waters near the respective colony. Prey size increased with progress of

chick growth indicating active selection of prey size with the increasing energetic requirements of growing chicks.

INTRODUCTION

Studying the diet of seabirds can provide a tool for assessing the type, size, mass and quality of prey available to them within their foraging areas during the breeding season (Dänhardt *et al.* 2011).

Diet composition is a major limiting factor in breeding productivity through its effect on growth and survival, as the energy and nutrients acquired are affected by the quality and quantity of food consumed which in turn affects growth rate (Wanless *et al.* 2005). Diet composition can also indicate the feeding regime of the parent bird as a generalist or specialist feeder (Nicholson 2002), and in turn how availability of prey population can impact the breeding success of a certain seabird species. Several factors can affect the diet composition of seabirds (Table 1).

Lesser Crested Terns of the subspecies *emigrata* are breeding only in Libya at

Factor	Reference
Seabird body morphology and mass	Hulsman 1988
Weather conditions	Shealer 2002
Prey distribution pattern and availability at foraging areas	Carty 2009
Differences in prey size	Hulsman1981, McLeay <i>et al.</i> 2009
Differences in energetic efficiency between parent and young birds	
Position of prey with respect to the water depth, correlated to prey size.	Dänhardt & Becker 2011

Table 1. Factors controlling diet composition in seabirds

three colonies, Gara, Elba (Meininger *et al.* 1994), and since a later date the colony in Jeliana lagoon, Benghazi (Hamza *et al.* 2007). This species uses two main feeding techniques: plunging at the water surface (i.e. the bird dives into the water but does not submerge completely); feeding by aerial diving, which take place when the bird dives and submerges completely, relying on momentum to reach and catch its prey (Ashmole & Ashmole 1967). The preferred food is epipelagic and nektonic fish species, with a smaller proportion of benthic species such as crustaceans and cephalopods (Cramp 1985, del Hoyo *et al.* 1996, Hulsman *et al.* 1989). As previous studies on feeding ecology and diet structure in Lesser Crested Terns are few, there is a need to update existing information and to document data from poorly studied populations (Horn *et al.* 2010) as most published information on this subject is restricted to the Australian populations (Hulsman 1977, 1981 and 1988, Hulsman *et al.* 1989, Nicholson 2002). Information regarding diet structure and foraging of the Mediterranean breeding population in Libya is scarce, limited to seven fish species reported during a short visit to breeding sites in summer 1993 at the Elba and Gara colonies (Meininger *et al.* 1994).

No information was previously available on diet structure at the Jeliana breeding site (Benghazi) as it was discovered several years after Meininger’s report.

METHODS

Chick diet samples were collected during 2008-2010 and 2012 from Gara, Elba and Jeliana colonies. Regurgitates were hand-picked from chicks aged 1-3 weeks during ringing operations. Regurgitates collection is the method of minimal intrusion to seabirds (Cooper & Klages 1995, Barrett *et al.* 2007), including terns (Nicholson 2002, Shealer 1998, Surman & Wooller 2003). Food discarded near nests was also collected and included in the data analyses. Diet samples were preserved in plastic bags and then kept in 70% alcohol, prior to identification at the Fish Biology laboratory of Tripoli University, and at the University of Omar Al-Mokhtar in the 2012 season. Whole prey items (fish) and partially digested fish/cephalopods (where length could still be estimated) were included in the analyses. Total length (mm) and weight (g) of regurgitated fish was measured when the specimen is intact; when the specimen is partially digested, total weight was

calculated using allometric equations for that species listed in fishbase.org (Froese & Pauly 2000).

RESULTS

A total of 422 diet samples belonging to 18 families of fish and one family of cephalopods were collected during the 2008-2010 and 2012 breeding seasons.

At Gara Island, nine species of fish and one cephalopod species (*Loligo sp.*) belonging to 10 families were collected from regurgitated food and adjacent nest discards. 13 fish species belonging to nine families were collected from the Elba Island colony, and 18 species of fish belonging to 13 families were collected at the Jeliana islet, most of them during the 2008 and 2012 seasons. Details of prey species at each breeding site is listed in Table 2.

	Family	Species	Gara	Elba	Jeliana
1	Atherinidae	<i>Atherina boyeri</i>			
2	Belonidae	<i>Belone belone</i>			
3	Blenniidae	<i>Lipophrys trigloides</i>			
		<i>Salaria pavo</i>			
4	Carangidae	<i>Seriola dumerili</i>			
5	Centranchidae	<i>Spicara smar</i>			
6	Cichlidae	<i>Tilapia zilli*</i>			
7	Clupeidae	<i>Sardinella aurita</i>			
8	Coryphaenidae	<i>Coryphaena hippurus</i>			
9		<i>Lichia amia</i>			
10	Engraulidae	<i>Engraulis encrasicolus</i>			
11	Exocoetidae	<i>Cheilopogon heterurus</i>			
12	Hemiramphidae	<i>Hemiramphus far</i>			
13	Labridae	<i>Coris julis</i>			
14	Loliginidae	<i>Loligo vulgaris**</i>			
15	Pomacentridae	<i>Chromis chromis</i>			
16	Scaridae	<i>Sparisoma cretense</i>			
17	Scombridae	<i>Scomber scombrus</i>			
18	Siganidae	<i>Siganus luridus</i>			
		<i>Siganus rivulatus</i>			
19	Sparidae	<i>Boops boops</i>			
		<i>Lithognathus mormyrus</i>			
		<i>Sarpa salpa</i>			
		<i>Diplodus vulgaris</i>			
		<i>Diplodus sargus</i>			
		<i>Oblada melanura</i>			
		<i>Pagellus erythrinus</i>			

Table 2. Taxa constituting the chick diet of Lesser Crested Tern *Sterna bengalensis emigrata* in Libya. * Freshwater/brackishwater fish species. ** Squid (Mollusca).

TOTAL PREY LENGTH AND PREY MASS DISTRIBUTION

The total length of collected fish specimens (whole and partially digested fish) ranged from 26.8-150 mm (mean = 77.34 ± 21.8) at Jeliana, 32-140 mm (mean = 77.7 ± 25.1) at Elba and 33-109 mm (mean = 63.4 ± 20.0) at Gara. The percentage frequency distribution of fish length shows some variable trends between the sites (Figure 1). At Jeliana, most fish ranged from 50 to 100 mm while at Elba, about 25% of the fish sampled were in the 100-140 mm category, and at Gara about 70% of fish length was in the 40-70 mm category (Figure 3).

Total prey length in the samples represents either planktonic or juvenile fish stages, as these terns actively select prey that suit the maximum gape opening of both adult and young terns (Hulsman 1981). Terns fed on larger fish at the Jeliana and Elba colonies compared to the Gara colony. The pooled reconstituted mass for regurgitated fish at Jeliana ranged from 0.3-41.2g (mean = 6.1 ± 5.9 , $n = 249$), at Elba it ranged from 0.1-19 g (mean = 5.1 ± 4.3 , $n = 70$), while at Gara it ranged between 0.3-25.7g (mean = 3.3 , ± 2.6 , $n = 103$).

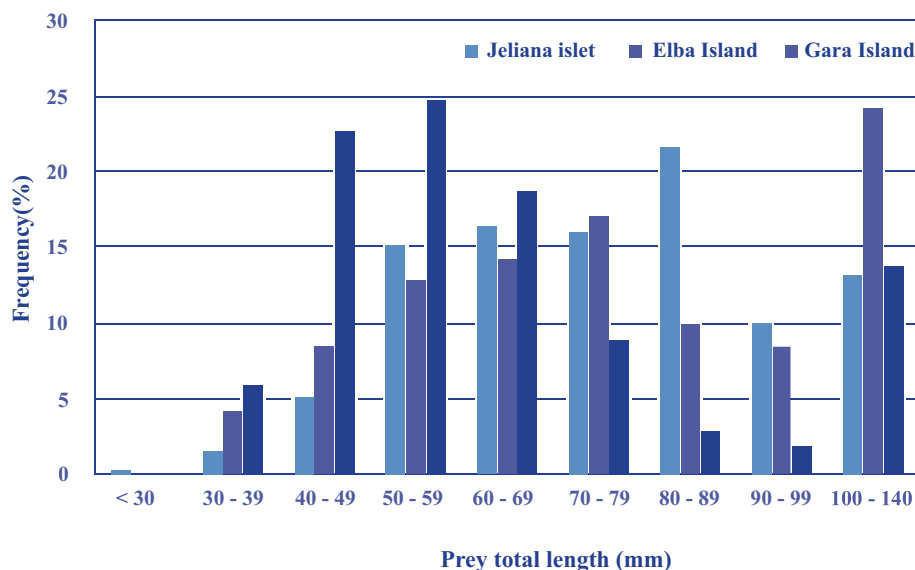


Figure 1. Percentage frequency distribution of total prey length (mm) collected from Lesser Crested Tern *Sterna bengalensis emigrata* chicks at the Gara, Jeliana and Elba colonies, Libya.

DISCUSSION

Ten fish species and one cephalopod from Gara, 12 fish species from Elba, and 18 fish species from Jeliana, were found to make up the diet of young Lesser Crested Terns at the three main breeding sites of the species in Libya. From the sample sizes collected, the majority of fish are either planktonic (larval) or the juveniles of demersal species. During this phase, many of these species tend to occupy the upper layer of the water column, searching for food (mainly zooplankton and phytoplankton) and use seagrass meadows of *Posidonia oceanica* as a shelter from predators. Meininger *et al.* (1994) mentioned four fish species in the diet of young Lesser Crested Tern at the Elba colony: bogue *Boops boops*, garfish *Belone belone*; Sand eel *Gymnammodytes cicerelus*; and a probable grey mullet (Mugilidae). No sand eel specimens were found in the Elba diet samples in the present study, which may indicate changes in structure of the local fish assemblage around this breeding site (alternatively, although one specimen of sand eel was recorded in Meininger's study, it may not be a preferred food for the terns in Libya). At Gara all the prey species mentioned by Meininger *et al.* (1994) were also found in our study. However, Meininger *et al.* did not mention either the Black-barred halfbeak *Hemiramphus far* nor the Mediterranean Flying fish *Cheilopogon heterurus* which might be explained by the later establishment of Black-barred halfbeak populations in Libya (first reported 14 years later by Shakman & Kinzelbach 2007) and possibly due to the low sampling effort for diet composition in the 1994 survey.

The highest number of prey species was found at Jeliana (19 species) possibly due to the large sample size (249 items) compared to the other two sites. However, Lesser Crested Terns from this colony appear to show a preference for foraging

at inshore shallow water sites (there are many inshore bays and coastal lakes at Benghazi, incl. Ain Ziana lagoon and Benghazi Lake), a lower proportion being observed using deeper offshore waters. Taking into account the importance of these inshore sites as fish nurseries (and a former fish aquaculture site at the Ain Ziana lagoon) the adult terns have an easy and proximal area for provisioning their young.

In conclusion, Lesser Crested Terns have been found to catch a wide range of fish size, with more preference for certain species being both easier to locate and of higher energetic value, thus fulfilling the high food demand for the young, with an active selection of larger prey during the later provisioning period, as the gape of the chicks becomes more adapted for receiving larger food items. The results of this study can be used as baseline data on feeding aspects of the Lesser Crested Tern young at the Mediterranean breeding sites. It shows that although several prey species are consumed by the chicks and nestlings (and possibly other prey species are being utilized by the adult terns), only a few species are of greater importance in terms of occurrence and mass. Any change in population dynamics of these preferred few prey species, due to fisheries or changing oceanographic/climatic conditions (e.g. sea surface temperature, circulation) over the foraging areas would have severe consequences on tern population dynamics (Wanless 2006).

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RAC/SPA

The Regional Activity Centre for Specially Protected Areas (RAC/SPA) was established in Tunis in 1985 by decision of the Contracting Parties to the convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention), which entrusted it with responsibility for assessing the situation of natural heritage and assisting the Mediterranean countries to implement the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD) Protocol which came into force in 1999.

RAC/SPA's mission is to provide assistance to Mediterranean countries in the implementation of their commitments under the (SPA/BD) Protocol, especially in regard to developing and promoting Specially Protected Areas (SPAs) and reducing the loss of marine and coastal biodiversity.



MEDMARAVIS

MEDMARAVIS is an international NGO dealing with the study and conservation of coastal habitats and marine avifauna throughout the Mediterranean region. Its main goal is to study, monitor, and protect coastal biotopes, with main focus on small islands, unspoilt coasts, and seacliffs which harbour breeding seabirds and other endemic or threatened species. Medmaravis, enjoying a network of marine biologists, ornithologists and conservationists, organizes a major seabird conference every three years. It is engaged in the compilation of a conservation strategy for the Mediterranean Sea, propagating the importance of the seabirds' rôle in the ecosystem, and encouraging governments and local authorities to protect the last wild coastal ecosystems in the Mediterranean countries. Since late 2014, as an effect of a liaison with the Conservatoire-du-Littoral (CdL, France), Medmaravis is in charge of producing simple and reproducible protocols that will be applied across the Mediterranean, in order to harmonize the methods applied to monitor chemical and plastic contaminants throughout the Mediterranean coast.

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