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DIET AND FEEDING STRATEGY OF *GALEUS MELASTOMUS* IN THE CONTINENTAL SLOPE OFF SOUTHERN PORTUGAL

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DIET
FEEDING STRATEGY
GALEUS MELASTOMUS
PORTUGAL

ABSTRACT. – Sixty individuals of *Galeus melastomus* were caught during an experimental survey using longlines carried out at depths between 950 and 1100 m along the south coast of Portugal during the second half of September 2003. Individuals ranged from 560 to 740 mm total length, with a large predominance of females. Myctophids, unidentified teleosts, *Sergia robusta* and *Histioteuthis meleagroteuthis* were the dominant prey categories. A prey diversity index was calculated as 2.96 and 46% of the stomachs with remains had more than one prey category. The vacuity index was 17%. The feeding strategy of *G. melastomus* is considered generalized since each individual feeds on several different prey types. Trophic level estimated for the species in the study area was 4.02, which is in agreement with other published data.

INTRODUCTION

Galeus melastomus Rafinesque, 1810 is a scyliorhinid species very common in north and central eastern Atlantic waters including the Mediterranean (Quero 1984, Carrassón *et al.* 1992, Correia & Figueiredo 1997, Moranta *et al.* 1998, Olaso *et al.* 2002). Size distribution varies with depth: young are mostly concentrated at shallower depths, whereas adult specimens (larger than 440 mm total length) are more frequent below 500 m (Rey *et al.* 2002, Carbonell *et al.* 2003, Massutí & Moranta 2003).

Although *G. melastomus* is not a targeted species in Portuguese fisheries operating in continental waters (Correia & Figueiredo 1997) it is the most important elasmobranch in the by-catch of longline vessels (Erzini *et al.* 2001). Elasmobranchs in general, and sharks in particular, are considered to play an important role in ecosystem food webs. However, little quantitative information is available on their diet and feeding habits (Cortés 1999). The diet of *G. melastomus* has already been studied in some areas of the Northeast Atlantic and Mediterranean (e.g. Capapé 1975, Relini-Orsi & Wurst 1975, 1977, Capapé & Zaouali 1976, MacPherson 1980, Mattson 1981, Carrassón *et al.* 1992, Bello 1995, Olaso *et al.* 2002) but in Portuguese waters there is limited information (Santos & Borges 2001). This paper intends to improve our knowledge of the trophic relationships and diet of *G. melastomus* for the southern slope of the Portuguese coast.

MATERIAL AND METHODS

Study area and sampling method: An experimental survey using longlines with 400 to 500 hooks was carried out by the

IPIMAR RV *Capricórnio* at depths between 950 and 1100 m along the southern coast of Algarve during the second half of September 2003. The Algarve region is located in the south of Portugal between Cape S. Vicente in the west and the Spanish frontier in the east (Fig. 1). This region has a complex bottom topography (Viriato & Figueiredo 1991) and is influenced by the Mediterranean Sea current.

Data analysis: Sixty individuals of *Galeus melastomus* were caught and measured to the nearest millimetre (Total Length - TL); sex and maturity were assigned individually. Stomachs were removed and kept frozen for later processing in the laboratory.

Food items in the stomach contents were identified to the lowest taxonomic level and counted. Stomachs containing only bait were excluded from all subsequent analyses. For each food item the numeric frequency (N) and frequency of occurrence (FO) were calculated. N is the total number of each food type expressed as a percentage of the total number of all food types in all non-empty stomachs, and FO is the number of stomachs in which a food type was found (Cortés 1997). The number of fish in each area with empty stomachs was expressed as a percentage of the total number examined (Index of vacuity - IV) (Ellis *et al.* 1996).

The Shannon-Wiener index (H') (Shannon & Wiener 1963) and prey evenness index (J) (Pielou 1966) were used to evaluate diet diversity:

$$H' = - \sum_{i=1}^n [p_i \times \ln(p_i)] \quad J = H' / \ln(S)$$

where p_i is the proportion of a specific prey category for the n categories of preys and S is the number of prey types identified. As recommended by Gelsleichter *et al.* (1999), a cumulative prey curve was constructed to determine whether an adequate number of fish had been collected to describe the diet precisely. The order in which stomachs were analysed was random-

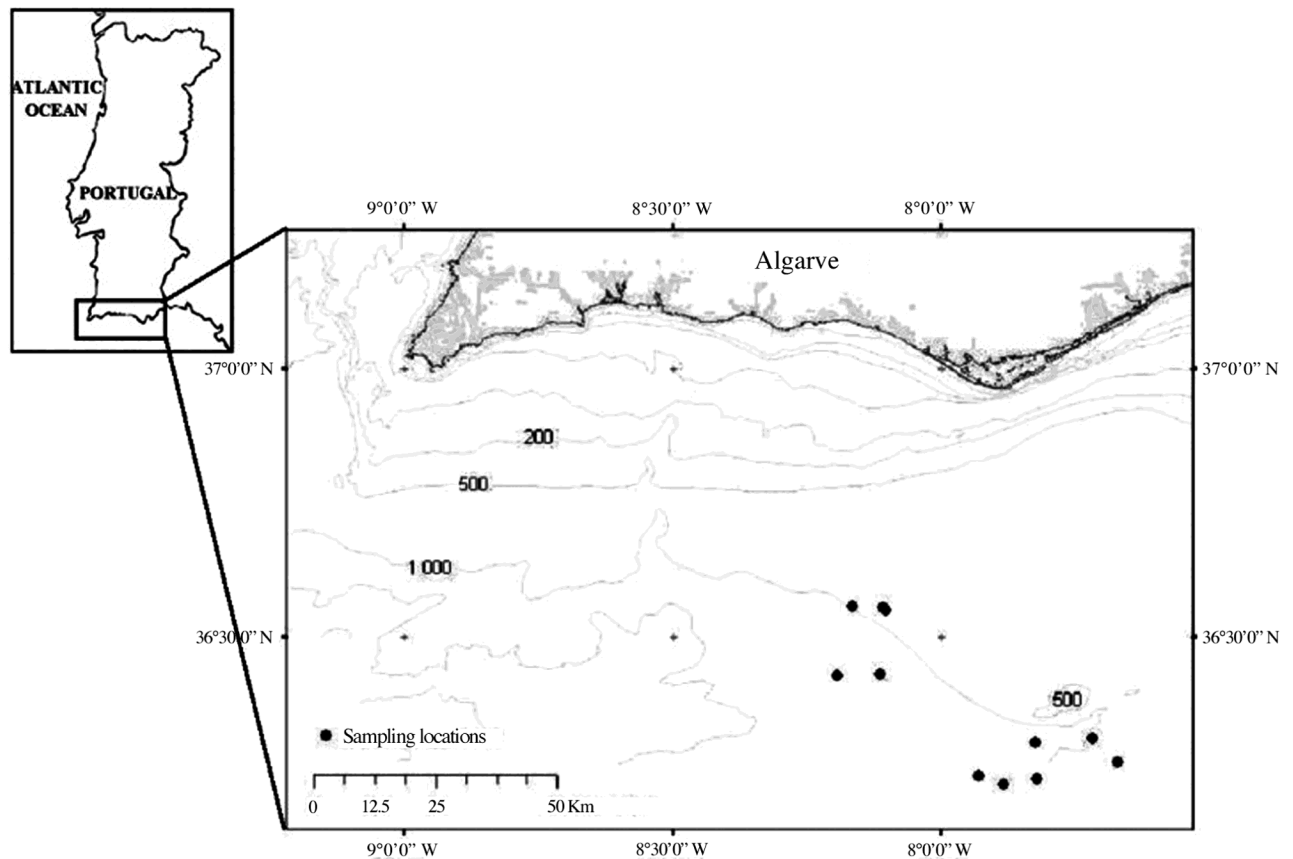


Fig. 1 – Map of the survey area off southern Portugal.

Table I – Prey categories and trophic levels used to calculate the diet composition of *Galeus melastomus*.

Species group	Trophic level	Trophic level reference
Decapod crustaceans	2.52	Cortés 1999
Cephalopods	3.2	Pauly <i>et al.</i> 1988
Teleost fishes	3.24	Cortés 1999
Stomiidae	3.95	www.fishbase.org
<i>Chauliodus sloani</i>	4.2	www.fishbase.org
Myctophidae	3.2	www.fishbase.org
<i>Micromesistius putassou</i>	3.7	www.fishbase.org
<i>Notolepis</i> sp	3.5	www.fishbase.org

ized ten times and the mean number of new prey species found consecutively in the stomachs plotted against the number of stomachs analysed (Ferry *et al.* 1997). Presence of an asymptotic relationship indicates that a sufficient number of samples has been analysed.

Trophic level (TrL), which is typically estimated from diet composition data, was estimated from the mean trophic level of prey types plus one (Cortés 1999) according to the following expression:

$$\text{TrL} = 1 + \left[\sum_{i=1}^8 (p_i \times \text{TrL}_i) \right]$$

where p_i is the proportion of each prey category i in the diet and TrL_i is the trophic level of each prey category i . Eight prey

categories, with their respective trophic level, were considered (Table I).

Prey-specific abundance (P_i) was plotted against the frequency of occurrence for the five major prey categories, following the procedure to evaluate the feeding strategy proposed by Amundsen *et al.* (1996):

$$P_i = \left[\frac{\sum S_i}{\sum S_{i_j}} \right] \times 100$$

where S_i is the number of prey i and S_{i_j} is the total number of stomach content in only those individuals with prey i in their stomach. This graphical approach provides insight on prey importance, feeding strategy and inter and intra-individual components of niche width.

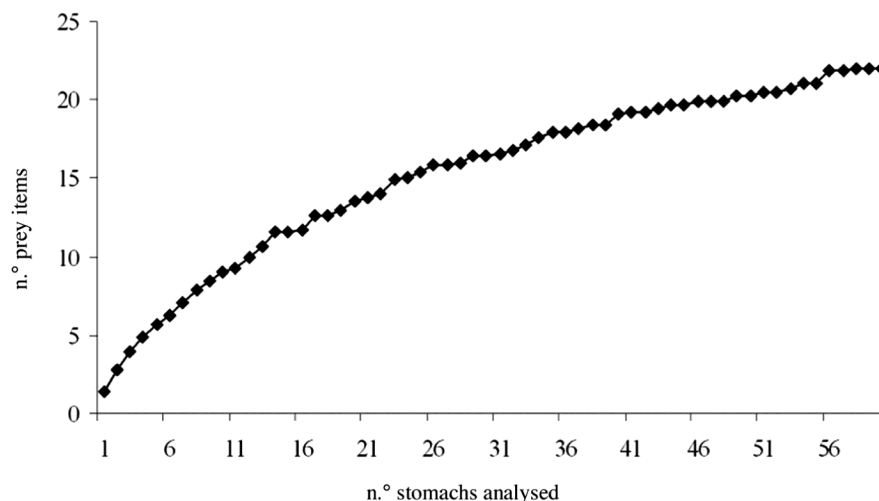


Fig. 2 – Cumulative prey curve for the stomachs of *Galeus melastomus*.

RESULTS

The catches consisted of 95% females. The 57 females ranged in size from 562 to 730 mm TL while the length of the three males ranged between 616 and 635 mm.

Prey composition in Galeus melastomus diet

Cumulative prey curves for all analysed stomachs indicated that the number of stomachs might have been sufficient to characterize the diet of *Galeus melastomus* in the area (Fig. 2). Twenty-two different prey categories were identified in all sampled stomachs, with Myctophidae, unidentified teleosts, the shrimp *Sergia robusta* (Smith, 1882) and the squid *Histioteuthis meleagroteuthis* (Chun, 1910) as the dominant prey categories (Fig. 3). At least 8 different species of the family Myctophidae occurred in the stomach contents although we could not identify them with certainty. In fact, only otoliths were present and usually quite eroded making identification very difficult.

Diet description and feeding strategy

The vacuity index was 17%. Of all stomachs with remains, 46% had more than one prey category. Teleostei were the dominant group category (57%) followed by crustaceans (33%) and cephalopods (10%).

The Shannon-Wiener diversity index was 2.96 with an evenness value of 0.87 and trophic level of 4.02, a value expected for a top predator with a diet based mostly on fishes and crustaceans. The diagram for the feeding strategy of *G. melastomus* caught in Algarve (Fig. 4) showed

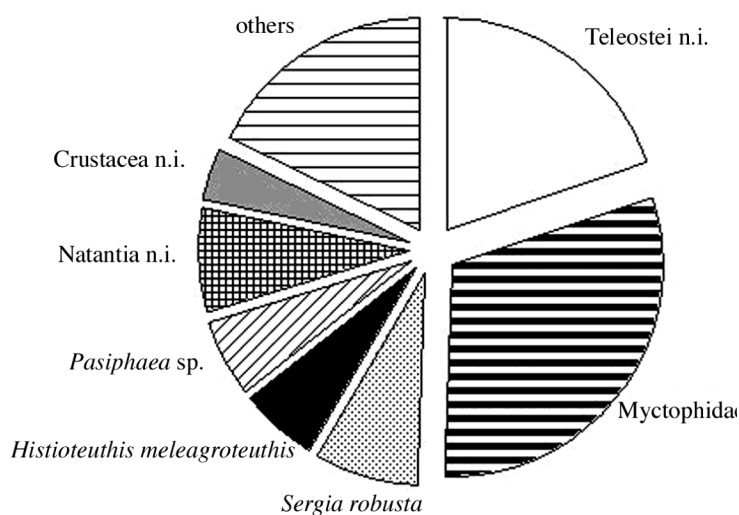


Fig. 3 – Percentage of each prey category in *Galeus melastomus* stomachs.

that teleosts, myctophids and crustaceans are the dominant prey for most individuals, whereas *Sergia robusta* and Cephalopoda are important preys in the diet of a lower number of individuals. The diet of this species in our study area can be considered somewhat generalized, since each individual tends to feed upon several prey types.

DISCUSSION

Similarly to the present study, the predominance of females above 500 mm TL has been reported for several Mediterranean areas, namely the Alboran Sea (Rey *et al.* 2002), Ionian Sea (Tursi *et al.* 1993) and Catalan Sea (Carrasón *et al.* 1992). The absence of juveniles in the catches is certainly related to the depths sampled in our research survey, since the shallowest depth at which the longline

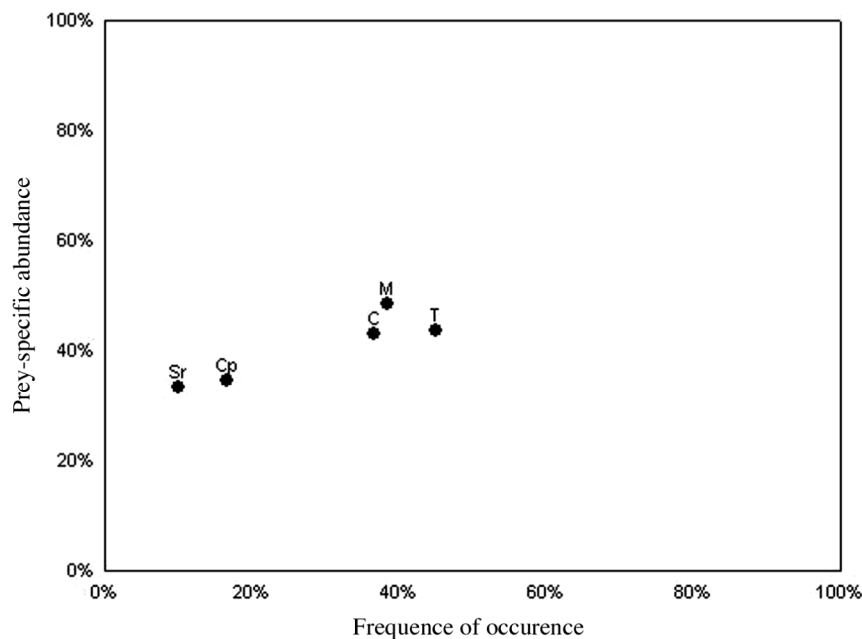


Fig. 4 – Feeding strategy diagram of *Galeus melastomus* (C – Crustaceans other than *Sergia robusta*; Cp – Cephalopods; M – Myctophids; Sr – *Sergia robusta*; T- Teleost fishes other than myctophids).

operated was 950 m and data from the Mediterranean showed that juveniles of *Galeus melastomus* mainly occur at depths shallower than 1000 m (Olaso *et al.* 2002, Masutí & Moranta 2003). According to MacPherson (1980), juveniles tend to feed on smaller prey (mainly euphausiids) and in shallower grounds, while teleosts and cephalopods are the most important prey for adults. The differences in feeding habits between young and adults thus probably reflect the species wide bathymetric distribution along the bathyal slope (Mattson 1981).

A large amount of bioluminescent preys such as *Sergia robusta*, *Pasiphaea* spp., and myctophids were dominant in the present study. These prey types have already been cited in the diet of individuals of similar size and also caught at depths deeper than 980 m (Carrassón *et al.* 1992). *G. melastomus* has large eyes which is probably an adaptation for feeding on such species.

Teleosts and Natantia crustaceans were the most important prey groups. These preys were also found to be dominant in other studies from the western Mediterranean (Capapé 1975, Capapé & Zaouali 1976, Carrassón *et al.* 1992), Cantabrian Sea (Olaso *et al.* 2002) and a Norwegian fjord (Mattson 1981). Euphausiids, which are a very common prey reported in several other studies (MacPherson 1980, Mattson 1981, Carrassón *et al.* 1992, Olaso *et al.* 2002), were absent in the stomach contents sampled because they are mainly preyed upon by small individuals (MacPherson 1980). Furthermore, the majority of *G. melastomus* caught in our samples presented a somewhat generalized diet, with each individual tending to feed on a large number of prey categories. Information

obtained from several trawl surveys carried out by the IPIMAR RV Capricórnio and Noruega from 1995 to 2002 show high diversity and density of potential prey in the study area (IPIMAR, unpubl data).

The trophic level estimated in the present study is in agreement with other published data. Stergiou & Karpouzi (2002) calculated a trophic level of 4.2 for *G. melastomus* ranging in length from 400 to 600 mm and caught deeper than 990 m. Cortés (1999) estimated a trophic level of 3.7 using information from several studies around the world.

Individuals with high trophic level such as sharks, and specifically *G. melastomus*, are relatively abundant marine consumers and can potentially influence the aquatic communities in which they occur (Cortés 1999). The trophic position of individual species needs to be understood to gain insight into the functioning of the entire community. In this context, the study of diets of deepwater species can be seen as another source for improving the characterization of deepwater faunal communities.

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