Journal of Marine Systems 159 (2016) 100–108

Contents lists available at ScienceDirect

Journal of Marine Systems

journal homepage: www.elsevier.com/locate/jmarsys

Diet and trophic ecology of the lanternfish *Electrona risso* (Cocco 1829) in the Strait of Messina (central Mediterranean Sea) and potential resource utilization from the Deep Scattering Layer (DSL)

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ARTICLE INFO

Article history:
Received 17 December 2015
Received in revised form 15 March 2016
Accepted 16 March 2016
Available online 24 March 2016

Keywords:
Diet
Prey
Stomach content
Feeding strategy
Lanternfish
Mediterranean Sea

ABSTRACT

The feeding habits of the mesopelagic lanternfish *Electrona risso* from the Strait of Messina (central Mediterranean Sea) were analyzed for the first time. A total of 326 individuals were collected stranded along the Sicilian coast of the Strait of Messina from October 2012 to May 2013. Specimens ranged from 12.0 to 53.8 mm L_S (mean $L_S = 38.6 \pm 8.4$ mm). Their stomach content was examined and prey composition and feeding strategy were investigated.

The results indicate that *E. risso* is a specialist predator, which feeds mainly on the small mesopelagic fish *Cyclothone braueri* (%*IRI* = 74.06) and in minor proportion on zooplankton, with a prevalence of copepods. The specialized feeding strategy of *E. risso* is confirmed by the low value of Levins standardized index ($B_j = 0.141$), which indicated a restricted niche breadth. The value of the index of trophic level (*TROPH*) for *E. risso* resulted 4.20. The prey composition suggests that *E. risso* can be considered a weakly vertical migrating species, that feeds on the DSL crustacean and fish communities below 300 m of depth.

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1. Introduction

Due to their high density and wide diffusion, mesopelagic fish can be considered the most abundant vertebrates on earth (Mann, 1984). Myctophidae is a fish family which includes a large number of small pelagic teleosts (about 33 genera and more than 250 species; Catul et al., 2011) occurring in mesopelagic and bathypelagic waters of all oceans. The importance of myctophids in the pelagic trophic web is well known and is due to several reasons:

i) Myctophids are characterized by high biomasses (Gjøsaeter and Kawaguchi, 1980), sometimes dominating the mesopelagic fish assemblage (e.g. Valinassab et al. 2007). These abundances and widespread distribution support many pelagic predators of higher trophic levels.
ii) A large number of these species perform extensive vertical diel migrations, generally from depths around 1000–2000 m to the sea surface at night to feed on zooplankton and micronekton and thereafter they migrate down to stay in deep waters during daytime (Gjøsaeter and Kawaguchi, 1980; Catul et al., 2011). These migrations have an important role in the energy transfer from sea surface layers to the deep environment.
iii) The energetic value of myctophids as prey allows many pelagic predators to rely on these species to obtain a significant energy intake. Indeed, myctophids have a higher lipid content (e.g., wax esters) than several other fish species (Saito and Murata, 1998; Lea et al., 2002). This feature is probably linked to an adaptation at life in deep waters, where the regulation of buoyancy and resistance to higher pressure are necessary for survival.
iv) Myctophids occupy an intermediate trophic position in the marine food web (Cherel et al., 2010) and are involved in the energy transfer from zooplankton to higher trophic levels.

For all these reasons, several myctophids are considered key-stone species of the pelagic food chain, being essential prey of important commercial fishes, in particular tunas (e.g. Kozlov, 1995; Karakulak et al., 2009; Battaglia et al., 2013) as well as other marine predators (Kozlov, 1995; Guglielmo et al., 1995; Marabello et al., 1996; Springer et al., 1999; Mateu et al., 2015).

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http://dx.doi.org/10.1016/j.jmarsys.2016.03.011
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Despite their importance, the Mediterranean myctophids are still poorly investigated and information is lacking on several aspects of their ecology, biology and distribution patterns. The majority of studies on myctophids can be referred to limited areas of Mediterranean (Balearic Islands, Strait of Messina and Sicily Channel) and reduced sampling periods (due to the high costs of research cruises). However, with respect to the past, during the last years the Mediterranean scientists have made a special effort to fill this gap and several studies on different ecological and biological aspects have been published (Battaglia et al., 2010, 2014, 2015; Olivar et al., 2012; Bernal et al., 2013, 2015; Fanelli et al., 2014; Valls et al., 2014; Mateu et al., 2015).

Data on feeding ecology of Mediterranean myctophids, gained by stomach content analysis, are available for *Diaphus metopoclampus* (Battaglia et al., 2014), *Hygophum benoiti* and *Myctophum punctatum* (Scotto di Carlo et al., 1982), *Lampanyctus crocodilus* (Stefanescu and Cartes, 1992; Fanelli et al., 2014) and *Lampanyctus pusillus* (Bernal et al., 2013). Moreover, Bernal et al. (2015) recently investigated the feeding strategy of some mesopelagic fishes in the western Mediterranean, reporting dietary data on 8 species of Myctophidae (*Benthosema glaciale*, *Ceratoscopelus maderensis*, *Lobianchia dofleini*, *H. benoiti*, *L. crocodilus*, *L. pusillus*, *M. punctatum*, *Notoscopelus elongatus*), whereas Valls et al. (2014) described the trophic structure of mesopelagic fishes in the western Mediterranean on the basis of the analysis of carbon and nitrogen stable isotopes in samples.

The aim of the present paper is to study for the first time the feeding habits of the electric lanternfish *Electrona risso* (Cocco 1829), in order to extend current knowledge on this poorly known Mediterranean myctophid. *E. risso* is a worldwide distributed myctophid (Hulley, 1984; Froese and Pauly, 2014), occurring in mesopelagic waters with a vertical distribution usually varying between 90 m and 750 m, depending on its diel migratory behavior (Hulley, 1984). In the upwelling area of the Strait of Messina (central Mediterranean) it can be frequently found stranded from November to May (Genovese et al., 1971). Until now issues regarding the ecology and biology of this species have been poorly addressed, with the exception of few information given by Battaglia et al. (2010). In the present study we investigated the diet composition of *E. risso* from the central Mediterranean Sea by stomach content analysis together with feeding strategy and niche breadth; moreover potential differences in diet depending on fish size and season were also tested by statistical methods.

2. Materials and methods

2.1. Data collection and laboratory analysis

From October 2012 to May 2013, 326 specimens were found stranded on the shore of the Sicilian coast of the Strait of Messina (Fig. 1), where the occurrence of mesopelagic and deep fauna is mainly determined by strong upwelling currents (Genovese et al., 1971). According to Battaglia et al. (2010), the biological material was collected before the sunrise, in order to avoid the competition of seabirds, ants and wasps and the sun's drying effect. Specimens were identified following Hulley (1984).

In the laboratory, each individual was measured by caliper to the nearest 0.1 mm (standard length, L_S), weighed to the nearest 0.01 g (total weight, W_T) and dissected in order to remove stomach. Stomach content analysis was performed by a stereomicroscope Zeiss Discovery V.8.

Prey identification was performed following taxonomic features reported by Boxshall and Halsey (2004) for copepods, Costanzo & Guglielmo (1976a,b) and Brinton et al. (2000) for euphausiids, Riedl (1991) for other crustaceans and invertebrates, Whitehead et al. (1984–1986) for fishes, but in some cases, fish prey were identified by observing the otoliths, according to Battaglia et al. (2010, 2015). Prey items were identified to the lowest possible taxonomic level, counted and weighed to the nearest 0.1 mg, after removing excess water with blotting paper (Battaglia et al., 2014). When entire prey were found the size of each individual was measured by microscope or caliper to the nearest 0.1 mm of total length and grouped in the following dimensional classes: 0–5 mm, 5–10 mm, 10–15 mm, 15–20 mm, 20–25 mm. If partially digested prey were found, size of individuals was determined by comparing them with intact specimens of the same species sampled in the Strait of Messina and adjacent areas (Scotto di Carlo et al. 1982, stored in the collection of University of Messina and ISPRA. In this case, biomass values were then calculated by assigning an average wet weight value to each

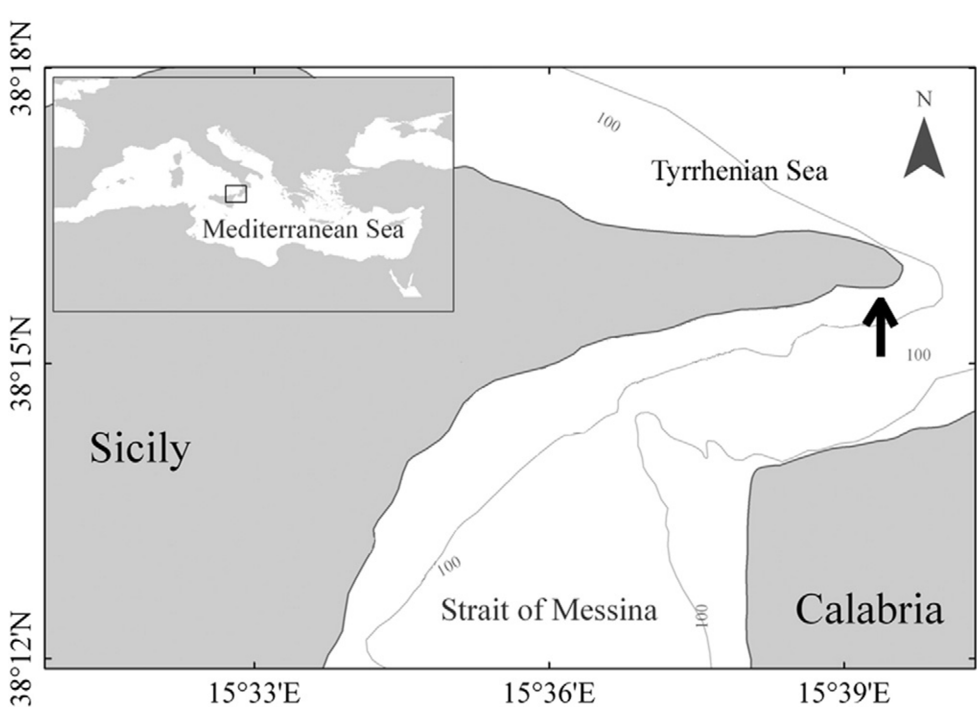

Fig. 1. Study area in the Strait of Messina (central Mediterranean Sea).

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