Estimates of trophic level in the red mullet *Mullus barbatus*: comparison between gut-contents and stable-isotope data

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The red mullet *Mullus barbatus* is one of the most economically important fish species in the Mediterranean Sea (Relini *et al.*, 1999). Recent research has demonstrated that in many areas it is overfished and that a prolonged (Potoschi *et al.*, 1995; Pipitone *et al.*, 1996) or temporary ban (Cau *et al.*, 1993) on trawl fishing can markedly increase its biomass. Pipitone *et al.* (1996) reported that after a 4-year closure of the trawl fishing in the Gulf of Castellammare (Sicily), its average catch per unit of effort (cpue) increased by approximately 25 times. The success of this species following the trawling ban may be related to its ability to efficiently exploit the food resources available (Vassiliopoulou and Papacostantinou, 1993). The red mullet is a specialised feeder on soft sandy/muddy bottoms (Badalamenti *et al.*, 1993) and shows a marked selectivity for several polychaete species (Lipari *et al.*, 1998).

Despite the appreciation that red mullet responds markedly to protection in trawlable areas, studies on its feeding habits are scarce and there is little quantitative knowledge concerning its position in the Mediterranean soft-bottom food webs. The present study aims to provide new information on the feeding patterns and trophic level of the Mediterranean red mullet. Herein we (1) estimate its average trophic level using stomach-content data, (2) study the variation that exists in trophic level in relation to fish size, using stable-isotopes of nitrogen, and (3) compare the estimates of trophic level obtained using the two methods (stomach contents and stable isotope data).

MATERIALS AND METHODS

All the specimens were caught using professional fishing vessels at depths between 20 and 200 m. The lengths and weights of freshly caught fish were measured and guts and white muscle samples were removed and stored in formalin or dried in the oven, respectively.

Gut-contents data

A total of 277 specimens of *M. barbatus* were caught between June 1994 and March 1995, with an average total length (TL) of 15.0 cm ± 1.5 (SD). Prey items were identified from stomach contents, to the lowest taxonomic level possible, and trophic level was calculated according to Mearns *et al.* (1981).

Stable-isotope data

A total of 16 red mullets were caught in December 1999, in order to compare the results obtained through the isotope analysis with those from the gut content analysis. The average total

length of the specimens was 15.2 cm ± 0.7 (SD). In addition 18 specimens, with sizes ranging between 9 and 24 cm TL, were also collected and divided into 3 size classes (small, medium and large), in order to assess differences in average trophic level with size. White muscle tissue was sampled from near the dorsal fin of each fish (Pinnegar and Polunin, 1999) and mesozooplankton was used as a reference material, assuming that most herbivorous zooplankton (*e.g.* calanoid copepods) possess a trophic level of 2. It was also assumed that with each trophic interaction $\delta^{15}N$ increased by 3.4‰ (DeNiro and Epstein, 1981; Minagawa and Wada, 1984).

RESULTS

The isotopic analysis gave a mean trophic level of 4.05 ± 0.26 (SD), which is significantly higher ($P<0.001$) than the mean trophic level calculated from the gut-contents analysis, which was 3.46 ± 0.30 (SD). Average $\delta^{15}N$ and trophic level of the three *M. barbatus* size classes ranged from 9.41 and 3.80 respectively for small specimens, to 11.38 and 4.38 for large ones (Table 1). The mean $\delta^{15}N$ and trophic level differed significantly ($P<0.05$) with size class, being significantly higher for large and medium sizes in relation to the small ones (Table 2).

Table 1. Average $\delta^{15}N$(‰), trophic level values and standard deviation (SD) of different size classes of the red mullet *Mullus barbatus* from the gulf of Castellammare

Size class	n	$\delta^{15}N$(‰)	SD	Trophic level	SD
small	6	9.41	0.61	3.80	0.18
medium	6	10.95	0.29	4.26	0.09
large	6	11.38	0.36	4.38	0.11

Table 2. **a)** Results of ANOVA on $\delta^{15}N$(‰), for the 3 size classes of the red mullet *Mullus barbatus* from the gulf of Castellammare, ***p<0.001. **b)** SNK test of the factor Class size, >=p<0.05

a) ANOVA

Source of variation		$\delta^{15}N$(‰)	
	df	MS	F
class size	2	6.43	32.44 ***
residuals	15	0.20	

Cochran's test C = 0.63, p> 0.005

b) SNK

Large = Medium > Small

DISCUSSION AND CONCLUSIONS

The average trophic levels calculated for the red mullet in the Gulf of Castellammare were higher than those for other benthic species of similar sizes collected in the same area. Using gut-content data, Badalamenti and D'Anna (unpublished report) found lower values for *Lithognathus mormyrus* and *Diplodus annularis*, *D. sargus* and *D. vulgaris*. Pinnegar (2000) reported average trophic levels for 10 Mediterranean shallow water fish species collected in the rocky littoral area of the Bay of Calvi (Corsica) and three sites in Mallorca (Spain). The average trophic level of all 10 species did not generally exceed 4.1, which is higher than the value we report here for the small size class of red mullet but lower than those for the medium and large size classes. Furthermore, Pinnegar (2000) reported that large-sized top predators, such as *Dentex dentex*, *Epinephelus marginatus*, *Seriola dumerili*, *Sphyraena sphyraena* and *Coryphaena hippurus*, exhibited average trophic levels between 4.0-4.4, whilst Herod *et al.* (unpublished data) estimated similar values for Mediterranean deep-sea macrourids and sharks. These values are similar to those of large-sized red mullet.

The high trophic position occupied by red mullet in the Mediterranean benthic food web may be explained by its diet, which consists largely of carnivorous polychaete species belonging to the Polynoidae and Sigalionidae families. Lipari *et al*. (1998) showed that adult red mullet exhibit a preference for only one species, the sigalionid *Sigalion squamatum*. Variation in the trophic levels calculated for the different-size classes of individuals may reflect differences in the diet of smaller specimens, which consume more crustaceans and bivalves (Vassiliopoulou and Papaconstantinou, 1993) and smaller-sized prey (Labropoulou and Eleftheriou, 1997).

The trophic levels obtained from isotope data analysis would place red mullet high in the marine food web. It remains to be understood whether or not individual food chains supporting benthic fish species are longer than previously supposed.