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Meridionalization as a Possible Resource for Fisheries: The Case Study of *Caranx rhonchus* Geoffroy Saint-Hilaire, 1817, in Southern Italian Waters

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Abstract: Climate change affects the shift range distribution of species, especially among mobile species, and this phenomenon can alter ecosystems and impacts human activities. Fishing is an anthropic activity that undergoes the effect not only of the introduction and increase of non-native species but also of native thermophilic ones. Some of these species can become a commercially exploitable resource. However, this information is often obscured by the negative effects these species can cause to the environment. We investigated how the thermophilic species *Caranx rhonchus*, neglected in Italy, could become a relevant resource. We studied the nutritional profile and the presence of heavy metal contamination and compared these traits with those of a similar common Mediterranean species, namely *Trachurus trachurus*. The proximate composition was determined following the AOAC procedure, while the fatty acid profile was determined by GC/MS, and the mineral component was obtained by mass spectrometer (ICP-MS). *Caranx rhonchus* is a nutritionally good species, although it is little consumed and exploited. Increasing the market supply with new commercially exploitable emerging species would benefit local communities and the environment. Therefore, it is necessary to investigate how a shift of the range caused by climate change can provide benefits within the human dimension.

Keywords: Carangidae; thermophilic native species; commercial fish species; nutritional value; metal contamination; human consume

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1. Introduction

The Mediterranean Sea is one of the most vulnerable areas to climate change, with dramatic effects favoring the spread of non-indigenous and thermophilic native species [1,2]. In particular, the range shift of species in the Mediterranean Sea is caused by two distinct phenomena: tropicalization, with non-indigenous species introduced by human activities (e.g., Suez Canal and ballast waters) [1], and meridionalization, with the northwards expansion of species usually restricted to the warmer southern part of the Mediterranean Sea [3]. The increase in water temperature has triggered rapid shifts in the range distribution of species [4–6]. These shifts have a direct effect on different habitats by reshaping local biocommunities [7,8], and on human activities [9]. Fisheries undertake an anthropic activity strongly affected by the shifting range distribution of aquatic species [10–13], with repercussions along social and economic dimensions of these social-ecological systems [14,15]. On the other hand, some Mediterranean fisheries have benefited from the presence of these species [16,17]. Indeed, many non-native species have become targets for fisheries, [18–20] and several Mediterranean fisheries have become dependent on the economic returns from the fishing of these species [18,21,22]. Many studies highlight the negative effects caused by the expansion of non-native invasive species, such as pest introduction [23,24], economic damage [25,26], and health risks [27–29]. Simultaneously, although rarely documented, non-native species can also contribute to the local economy by becoming a new resource, e.g., food [30]. Some of these species may become targets of local fisheries [31,32] but their economic benefit may be obscured by the negative impact on native species and habitats [33]. Non-native species often have a similar morphology and taste to local ones and can therefore be potentially easily commercialized. For example, the Lessepsian species *Upeneus moluccensis* Bleeker, 1855, and *Upeneus pori* Ben-Tuvia & Golani, 1989, have become highly sought-after resources due to their similarity to the two indigenous Mullidae species *Mullus barbatus* Linnaeus, 1758, and *Mullus surmuletus* Linnaeus, 1758, that are highly valued in the Mediterranean [19,34]. Another example is the species *Nemipterus randalli* Russell, 1986, first recorded in the Mediterranean in 2005 [32]. This species, however, was readily incorporated into markets as it is very similar in morphology and size to the native Sparids [35]. The use of non-indigenous species as human food resources can be compared for some aspects to that of neglected native ones. For example, a similar case in Italy can be seen in the false scad *Caranx rhonchus* Geoffroy Saint-Hilaire, 1817, a thermophilic species morphologically similar to a commercially well-known species *Trachurus trachurus* (Linnaeus, 1758) both caught in the same season using the same fishing techniques. In Italy, *C. rhonchus* is uncommon, although occasionally caught, especially along the Sicilian coasts, where it seems to have undergone a marked increase in abundance in recent years [36,37].

The false scad is a member of the family Carangidae, whose distribution extends in the eastern Atlantic, from Morocco to Namibia, and in the Mediterranean Sea, mainly along the African coast [38]. In the Gulf of Gabes (Tunisia), this fish is abundant and represents an important commercial species for fisheries [39]. However, despite its increasing abundance along Sicilian coasts (central Mediterranean Sea), this species can be considered commercially neglected, although it is occasionally present in local fish markets of south Italy, where it has a medium commercial value of EUR 10–12/kg and is sold as *T. trachurus*. The false scad can be considered a semi-pelagic fish, being both reported near the surface and near the bottom, along coastal marine waters (from a few meters of depth up to approximately 200 m) [38]. The false scad is an opportunistic piscivorous, whose diet partially overlaps with that of the greater amberjack, *Seriola dumerili* (Risso, 1810) [40]. On the other hand, it was found to be one of the main food items in the diet of the European hake, *Merluccius merluccius* (Linnaeus, 1758) [41].

In this study, we explored the positive opportunities provided by the phenomenon of meridionalization, analyzing the case of *C. rhonchus*. We acquired more information on the nutritional characteristics of the species in order to favor the regular introduction of this product among the species of consumer choice. In addition, we investigated the presence of heavy metal (and trace elements) in the meat of the species, for the assessment of the risk for human consumption. In order to facilitate the marketing of this species in Italy and in Mediterranean countries in general, the fillet quality traits of this neglected species, whose abundance is increasing in Italy, were compared with those of the Atlantic horse mackerel (*T. trachurus*), a well-known commercial fish species under whose name is also sold *C. rhonchus*, along the Sicilian coasts.

2. Materials and Methods

2.1. Samples and Sampling Areas

Samples of false scad specimens of commercial size were provided by fishermen of the small artisanal fishery that had caught them within three miles from the seashore, along the eastern coast of Sicily in front of the area located between Catania and Portopalo di Capo Passero (Figure 1), between October and December 2020. Twelve male specimens were immediately measured in weight (g) and length (cm). Measurements were performed using an electronic scale (mod. CP224S Sartorius, Gottigen, Germany) and an ictiometer. Each fish was immediately beheaded, eviscerated, and filleted. The edible part of each specimen was removed, separately homogenised, and codified; the samples were stored at −18 °C and transported in dry ice to the laboratory of Camerino University to determine the proximate composition, the fatty acid profile, and the determination of elements. The same was performed for twelve male specimens of the Atlantic horse-mackerel (*T. trachurus*), with similar body weight and captured in the same area. Here we provide a photographic comparison between the two species, remembering that, at the fish market, *C. rhonchus* is sold under the name of *T. trachurus*, together with true specimens of this latter species (Figure 2).

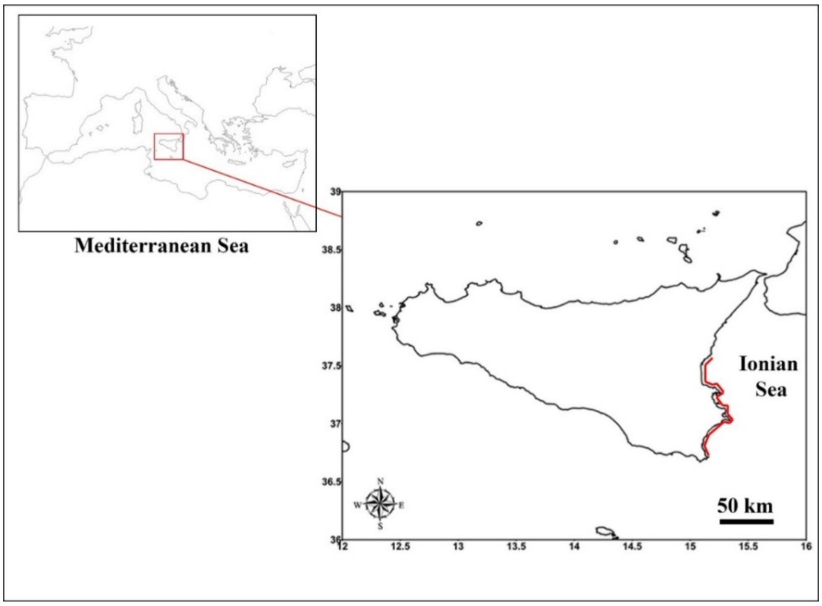

Figure 1. The image shows the sampling area; the red line indicates the area where *C. rhonchus* and *T. trachurus* were captured.

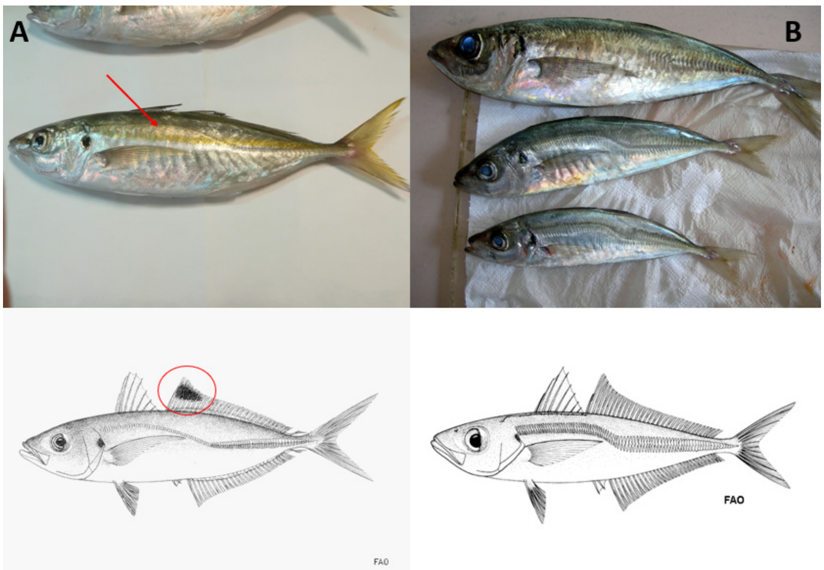

Figure 2. The image shows the comparison of the morphological differences between the two species *C. rhonchus* (**A**) and *T. trachurus* (**B**). The red arrow shows the yellow band along the body, while the red circle shows the black spot on the beginning of the second dorsal fin in *C. rhonchus*, both absent in *T. trachurus*.

2.2. Proximate Composition

For both the species, the moisture percentage was determined following the procedure of the Association official Analytical Chemists (AOAC) [42]. Total lipid content was measured using a modification of the chloroform:methanol procedure described by [43]. Proteins were determined using the standard Kjeldahl copper catalyst method. Ash was determined using the AOAC procedure.

2.3. Fatty Acid Profile Determination

In the pool of the two fish samples, after determining the total lipid content, the fatty acids were converted to methyl esters following the method described by [44]. An Agilent Technologies GC/MS (6890N)/MSD (5973inert) system (Agilent, Palo Alto, CA, USA) equipped with a db5 column (60 mt, 0.25 mm) and calibrated was used for separation of fatty acid methyl esters. The operating conditions of the gas chromatograph were as follows: oven temperature was kept at 170 °C for 15 min, increased to 190 °C at a rate of 1 °C/min, then increased to 220 °C at a rate of 5 °C/min, and held at this temperature for 17 min. The temperature of the injector was 280 °C. Helium was used as the carrier gas at a constant flow of 1.0 mL/min. The identification of individual fatty acids was accomplished by comparing the observed retention times to fatty methyl esters of standard mixtures (37 FAME Mix, Supelco) and NIST MASS SPECTRAL DATABASE (NIST MS SEARCH 2.3) for mass spectrum.

2.4. Determination of Elements in Meat

The quantity of essential (selenium, iron, calcium, zinc, magnesium, sodium, and potassium) and non-essential elements (cadmium, chromium, mercury, cobalt, and lead) was determined using Agilent inductively coupled plasma with mass spectrometer (ICP-MS) 7800 model (Agilent, Palo Alto, CA, USA), an inductively coupled plasma with mass spectrometer (ICP-MS) system following the procedure reported by [45]. The calibration curve profiles were obtained using standard element solutions obtained by diluting the mother solution in 3% HNO_3 + 0.05% HCl with yttrium, scandium, terbium, and bismuth as internal standards.

2.5. Statistical Analysis

The results concerning the proximate composition, the fatty acid profile, and the minerals of the two fish species were submitted to one-way analyses of variance (ANOVA) [46]. Differences were considered significant at $p < 0.05$, and means were compared using the Student-Newman-Keuls (SNK) test.

3. Results

3.1. Morphometric Parameters

Total length and standard length and weight of measured specimens of both species are reported in Table 1.

Table 1. Mean size and mean body weight sampled in the two fish species.

	Caranx rhonchus	*Trachurus trachurus*
Total length (cm)	35.08 ± 3.7	27.2 ± 2.4
Standard length (cm)	29.9 ± 3.69	-
Total Body weight (g)	372.25 ± 31.27	348.06 ± 8.97

3.2. Proximate Composition and Fatty Acid Profile and Mineral Content

The proximate composition (Table 2) shows the presence of a good protein content without significant differences in both species. Lipids exhibited differences with the highest rate in the false scad compared to the Atlantic horse-mackerel. Notable differences, although very slight, were observed in the ash content. As concerns the fatty acid profile (Figure 3), the false scad showed the presence of the most representative fatty acids recorded in the Mediterranean fish, although differences were observed compared with the horse-mackerel. Among the SFA of the false scad, the most important fatty acid was represented by palmitic acid (16:0) followed by stearic acid (18:0); both the fatty acids were higher than the Atlantic horse-mackerel, and the total of SFA resulted the highest in the false scad. Among the MUFA, the false scad showed the prevalence of oleic acid (18:1) and palmitoleic acid (16:1) in proportions higher than the same fatty acids determined in the Atlantic horse-mackerel. As concerns the n-6 fatty acids, the three FA detected in the *C. rhonchus* were higher than the *T. trachurus*; however, due to the high standard deviation, the total of n-6 PUFAs resulted in similar percentages between the two fish species. In terms of n-3 PUFAs, the false scad had high proportions of EPA (20:5 n-3), resulting higher than the that determined in the Atlantic horse-mackerel, whereas DHA and DPA had a proportion lower than the Atlantic horse-mackerel. The results of the mineral contents of the edible part of *C. rhonchus* and *T. trachurus* are presented in Table 3. The false scad showed to have a mineral content and low amounts of heavy metals (Cd, Hg, and Pb) without significant differences compared with the mineral content of the *T. trachurus*.

Table 2. Proximate composition (g/100 g ww) of the edible part of *C. rhonchus* and *T. trachurus*. Different letters (a, b) in the same column show differences significantly different between the means ($p < 0.05$).

	Moisture	Protein	Lipids	Ash
Caranx rhonchus	74.99 ± 1.01	20.3 ± 0.93	2.34 ± 0.15 a	1.2 ± 0.1 b
Trachurus trachurus	78.09 ± 1.39	19.69 ± 0.11	1.09 ± 0.13 b	1.59 ± 0.22 a

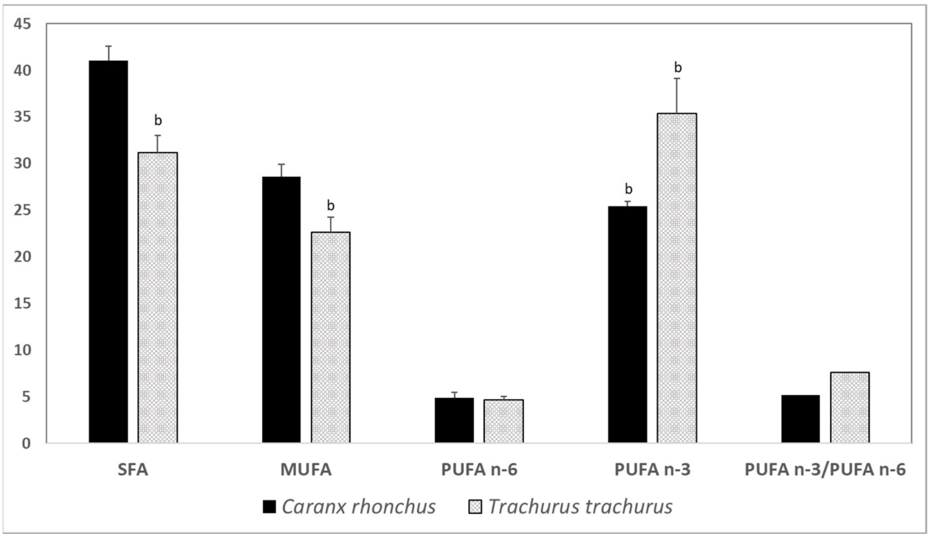

Figure 3. Fatty acid profile categories (% of the total fatty acids) and PUFA n-3/PUFA n-6 ratio of the two species. Different letters (a, b) in the same column show differences significantly different between the means ($p < 0.05$). SFA = Saturated Fatty Acids; MUFA = Monounsaturated fatty acids; PUFA = Polyunsaturated Fatty Acids.

Table 3. Trace elements and heavy metals content (mg/110 g ww) of the two species. Different letters (a, b) in the same column show differences significantly different between the means ($p < 0.05$).

		Caranx rhonchus	*Trachurus trachurus*
Calcium	Ca	98 ± 7.86 b	189.2 ± 4.38 a
Potassium	K	537 ± 38.06 a	413 ± 13.34 b
Magnesium	Mg	41 ± 6.67	40.4 ± 1.52
Sodium	Na	49 ± 5.6	49.4 ± 2.41
Iron	Fe	1.01 ± 0.098	1.59 ± 0.04

Table 3. *Cont.*

		Caranx rhonchus	*Trachurus trachurus*
Selenium	Se	0.066 ± 0.007	0.128 ± 0.08
Zinc	Zn	1.31± 0.07	1.11 ± 0.12
Cadmium	Cd	0.005 ± 0.003	0.011 ± 0.007
Mercury	Hg	0.03 ± 0.002	0.04 ± 0.001
Lead	Pb	0.017 ± 0.008	0.022 ± 0.004

4. Discussion

In this study, we have shown the potential of *C. rhonchus* for human consumption, providing new data on its nutritional values, trace elements, and heavy metals, satisfying the lack of information in this regard. The false scad is a thermophilic species that has increased its abundance in Italian waters [37], and in recent years it is commonly sold in fish markets, especially in those of southern Italy. Due to its similarity with species of the genus *Trachurus* Rafinesque, 1810, and to the fact that the species are often sold together, *C. rhonchus* generally goes unnoticed to consumers, who consume it as a species of the genus *Trachurus*. However, this species is sold under the common Italian name of "*Suro imperiale*" (or "*Sauro imperiale*"), demonstrating that fishmongers are aware that it is another species, although they consider it a *Trachurus* species (called "*Suro*" or "*Sugarello*"). As mentioned above, the species of the genus *Trachurus* and *C. rhonchus* are often sold together. Along the Sicilian Ionian coast, the catches of the false scad using trammel nets have increased in frequency and abundance over recent years (Tiralongo, F., personal observations, and [37]).

The comparisons of the edible parts between *C. rhonchus* and *T. trachurus* showed that the two fish species have remarkably similar nutritional profiles, especially as regards protein and mineral content. Iron, selenium, and zinc are present in quantities of interest for human consumption, while the heavy metal content is negligible in both species, not involving any risk to human health. The fat content is low in both species, but especially in *T. trachurus*, which also shows a higher level of n-3 PUFA fatty acids due to the higher percentage of DHA compared to *C. rhonchus* (27.37% and 17.51% as mean values, respectively), which shows a greater content of EPA and Arachidonic Acid. Overall, therefore, the quality traits of the false scad showed a high value due to high protein level, low lipid content, and high n-3 PUFA fatty acids.

In the central Mediterranean, specifically along the Tunisian coast, similar studies were carried out on smaller *C. rhonchus* individuals, weighing less than 100 g and with a length of less than 22 cm [47,48]. Comparison of the data obtained in these studies on male fish caught in the autumn shows similar values for moisture, protein, fat, and ash. Comparing the data collected by us with those reported in these studies, relating to male specimens fished in the autumn, reveals that similar values of moisture, protein, fat, and ash were detected; similarly, the content of heavy metals is also very low, while the mean value of iron is higher in our larger specimens than the smaller ones investigated in the other study (1.01 mg/100 g ww and 0.16 mg/100 g ww, respectively).

The results obtained show that *C. rhonchus* has high-quality nutritional properties, much like those possessed by *T. trachurus*. Therefore, this new emerging species has the characteristics to be valorized and marketed as well as *T. trachurus*, in order to implement awareness and a more sustainable exploitation of marine resources. The failure to properly exploit a species with good qualities such as *C. rhonchus* highlights the lack of data and consumers' awareness on new alternative species for consumption. There is the need to acquire information on which non-native and native thermophilic species in expansion can benefit the human dimension. Moreover, it has been observed that human consumption of marine invasive species could control their population's size [31,49–51].

The possibility of increasing supply with new resources makes it possible over time to lower the fishing pressure of the usual exploited species [51]. Several initiatives have already promoted the consumption of non-indigenous species, intending to inform consumers in order to turn them into a source of food and an economic benefit for local communities [52,53]. The same can also be applied to native thermophilic species, such as in the case here reported of *C. rhonchus*.

In conclusion, future scenarios will see the shift range of new species an increasingly common phenomenon in the Mediterranean Sea. The increasing number of non-indigenous species entering through the Suez Canal and thermophilic species entering through the Strait of Gibraltar or expanding their distribution from the southern Mediterranean Sea will change fisheries and species availability for human consumption in Mediterranean countries [1]. It is therefore necessary to understand how the shift range can benefit the human dimension and which non-indigenous and native invasive species can be commercially exploited. This is necessary for the proper management of fisheries and to guide consumers into more informed and responsible choices.

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