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Diet of the invasive piscivorous fish *Fistularia commersonii* in a recently colonized area of the eastern Mediterranean

S. Kalogirou · M. Corsini · G. Kondilatos · H. Wennhage

Abstract The composition of the diet of the Indo-Pacific cornetfish *Fistularia commersonii* from the SE Aegean Sea is described. The stomach contents of 245 specimens collected between September 2004 and March 2005 were examined. Dietary comparisons were made reflecting the relationship between diet composition, time of year, and fish size. Correlation between predator length and prey length was significant. The diet of the blue cornetfish consists of 96% by number and 99.95% by weight of fish. Size classification and habitat of prey groups (benthic, supra-benthic, and pelagic) showed that with increased body length the blue cornetfish extended its diet to larger prey and more generalist feeding. *Spicara smaris*, *Boops boops*, and Mullidae spp. were the most abundant prey by weight whereas a variety of small benthic fish (especially gobiids) and newly hatched fish constituted the largest number of prey items. Length–weight relationships for the cornetfish were investigated.

Introduction

More than 60 Erythrean fish species have entered the Levantine Basin via the Suez Canal and have established populations or are in the process of colonizing this region (Golani et al. 2002; Goren and Aronov 2002; Golani et al. 2004; Corsini et al. 2005). The continuous spreading of Erythrean invaders is changing the littoral and infralittoral biota of the Levantine Sea (Galil and Zenetos 2002). Alien species are an increasing problem in aquatic systems (Streftaris et al. 2005) and consequences for native and economically important species are poorly understood. The abundance of some Lessepsian migrant fishes has assumed economic importance in the south-eastern Levant and Anatolian fishery (Gücü et al. 1994; Torcu and Mater 2000; Golani et al. 2002; Cicek and Avsar 2003; Harmelin-Vivien et al. 2005) and other Erythrean invaders are a "nuisance or an economic burden", as assessed by Goren and Galil (2005).

The bluespotted cornetfish, *Fistularia commersonii* Rüppell, 1838 (Fistulariidae) inhabits shallow waters of coral and rocky reefs in tropical and subtropical Indo-Pacific regions (Fritzsche 1976). Rather common in the Red Sea, it frequents coral

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reefs, but also shallow sandy shores (Golani 1993a; Field and Field 1998; Golani 2000). In the Mediterranean Sea it was first recorded along the coast of Israel (Golani 2000), then at Rhodes Island, SE Aegean Sea, Greece (Corsini et al. 2002), along the Mediterranean coast of Turkey (Bilecenoglu et al. 2002; Cicek and Avsar 2003), in the NW Aegean Sea (Karachlé et al. 2004), and in the Central Mediterranean Sea (Azzurro et al. 2004). The most recent records reveal its rapid spread from the eastern to the central Mediterranean Sea. *Fistularia commersonii* is the only species of the family Fistulariidae present in the Levantine basin; in the Western Mediterranean, *Fistularia petimba* Lacepède, 1803, of Atlantic origin, has been recorded (Golani et al. 2002).

Fistularia commersonii is well established around the island of Rhodes (Corsini et al. 2005). During 2004–2005 the cornetfish was regularly present in autumn–winter trawl catches, ranging from 1 to 7.4% of the total catch weight, but was not commercially utilized (M. Corsini personal communication). It lives on sandy-muddy bottoms and *Posidonia oceanica* meadows, as observed also in Turkish waters (Bilecenoglu et al. 2002). Juvenile and adults are also observed in shallow waters around Rhodes city (beach, harbour) and juvenile specimens have been observed in shallow waters on sandy bottom rich in *Cymodocea nodosa* meadows, which may be considered as a nursery ground of the species in the area (M. Corsini, personal communication).

Documentation of the expansion of *F. commersonii* in the Mediterranean has been an important step in evaluating the success of this invasive species. Assessment of the ecological impact of *F. commersonii* will, however, also require better understanding of how the species interacts with other species in the food web. One important aspect of the ecology of an invasive species is the diet that it assumes after colonisation, and how this may affect native competitors and prey. *Fistularia commersonii* is primarily piscivorous in its original distribution range, mainly feeding on bottom-dwelling fishes, but supplementing its diet with squids and shrimps (Randall et al. 1997; Golani 2000; Takeuchi et al. 2002). In the Mediterranean Sea, information about its diet is limited to few specimens from the SE Aegean Sea (Corsini et al. 2002) and one specimen from the North Aegean Sea (Karachlé et al. 2004).

The purpose of this study was to describe the feeding ecology of *F. commersonii* in the Rhodes marine area during fall and winter. Size-related differences between prey items and their contribution in number and weight to the diet were assessed. The feeding habits determined were also used to evaluate the potential impact of this lessepsian immigrant on the native food web.

The length–weight relationship of this recent invader of the eastern and central Mediterranean Sea has been investigated for the first time.

Material and methods

Study site

The Gulf of Trianda, NW coast of the island of Rhodes, SE Aegean Sea, was selected for the study, because it is an important local fishing ground (Fig. 1). The area is characterized as soft, sandy to muddy bottom, interrupted by hard substratum and wide *Posidonia* meadows.

Collection of fish

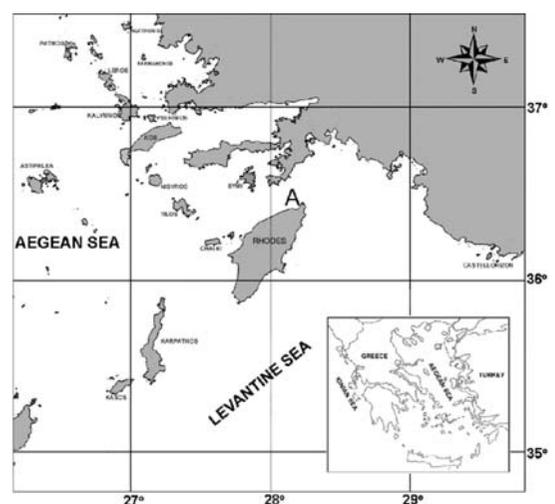A total of 245 *F. commersonii* specimens were captured during 2004 and 2005 (40 in September,

Fig. 1 Map of Rhodes and the Dodecanese Islands, with the sampling location of *F. commersonii* (**A**: Gulf of Trianda)

112 in October, 56 in December, 12 in February, and 25 in March), by trawling, and they were landed by the Hydrobiological Station of Rhodes and by local fishermen. Trawl mesh size increased from its lower bound (cod end) to its upper bound (8 mm, 11 mm, 12 mm, 32 mm, 1 m). Fishing took place during daytime at a depth of 30–40 m. All specimens collected were placed in labelled plastic bags and immediately transported to the laboratory where they were kept frozen at –17°C.

In the laboratory

Each specimen was thawed, measured (total length: TL, standard length: SL, accuracy of 0.01 cm), and wet weighed (accuracy of 0.01 g). The stomach–intestine was separated from the body and its contents removed. Prey items were counted by number and identified to the lowest taxonomical level possible, depending on the extent of digestion (well digested, partially digested, or fresh). Prey species were identified according to Smith and Heemstra (1986), Whitehead et al. (1986), and Bauchot (1987). After identification, each prey was wet weighted with an accuracy of 0.01 g and the SL was measured, with 0.001 cm accuracy, by use of a caliper. The length of unidentified prey items was also measured, when possible, and included for further analysis (for ''all prey'' in predator–prey size relationships). In one case only, four fishes contained in the buccal cavity were removed and not included as stomach content, because of the possibility of regurgitation. Immediately after analysis, the stomach contents were preserved in 10% buffered formalin.

All isopods (Fam. Cymothoidae) found in the stomachs were omitted from further analysis because they are well known ectoparasites on many of the prey fishes identified (Papapanagiotou and Trilles 2001).

Diet composition

The by-number (% N) and by-weight (% W) composition was determined for all identified prey, to quantify and evaluate their contribution to the diet.

Because of variation in the state of digestion of each prey species, biassed estimates of wet weights are commonly obtained (Toepfler and Fleeger 1995). Length–weight relationships were therefore obtained from the literature (Moutopoulos and Stergiou 2002; Stergiou and Moutopoulos 2001; Koutrakis and Tsikliras 2003; Froese and Pauly 2005), using the equation:

$$W = a\mathrm{SL}^b,$$

where W is the wet weight (g), a the intercept of the relationship, SL the standard length (cm), and b the slope. The large numbers of fresh specimens of *Spicara smaris*, *Boops boops*, and *Mullus barbatus* found in the stomachs made it possible to obtain a and b directly for these species. a and b resulting from the fitted models were used for determination of the weight of partially and well-digested prey with known SL. Further, the length–weight relationships of *F. commersonii* were calculated using the same procedure.

Feeding habits

To investigate feeding habits, prey species were pooled not only into taxonomic groups (i.e. families) but also into three functional groups—benthic, supra-benthic, and pelagic fishes, according to Goren and Galil (2001), depending on their habitat (Smith and Heemstra 1986; Bauchot 1987; Froese and Pauly 2005).

Predators were pooled into three size classes (SL): 0–350 mm (class 1), 351–700 mm (class 2), and 701–1050 mm (class 3). Fish length was plotted against prey length to assess any relationship between predator size and prey size, for benthic, supra-benthic, pelagic prey and for all prey combined. Sperman's nonparametric correlation test was used to examine the significance of the correlation between predator and prey length.

Temporal variation

Temporal variation was examined according to Tesch (1968) and Lizama and Ambrosio (2002), to describe seasonal variations. Seawater temperature was monitored at 32 m depth by the Hydrobiological Station of Rhodes, in an area close to the sampling location. Monthly averages were (°C ± SD): September 21.05 ± 1.30; October

21.97 ± 0.97; December 19.30 ± 0.48; February 16.60 ± 0.14; March 16.83 ± 0.60. September and October catches were in autumn and February and March catches were in winter, reflecting differences in seawater temperatures. Values of the condition factor for *F. commersonii* in autumn and winter were obtained by use of the formula:

$$CF = W/SL^b,$$

where CF is the condition factor, W the total weight (g), SL the standard length (cm), and b a term resulting from the length–weight relationship obtained for all *F. commersonii* specimens. Because of the difference between the number of samples in the different seasons (autumn: $n = 152$, winter: $n = 37$), 37 specimens from autumn were randomly selected to test differences between condition factors in different seasons using one-way ANOVA. In accordance with Tesch (1968), the following ratio for each fish was also examined:

$$K = W_o/\hat{W},$$

where W_o is the observed weight (g) and $\hat{W}$ is the expected weight (g) from the length–weight relationship for all the individuals caught.

Results

Diet composition

Among the 245 specimens examined, 38 had empty stomachs (one caught in September, one in October, 14 in December, 8 in February and 14 in March). Fish were the predominant prey by number, making up 96% of the stomach content; sub-adult Decapoda Natantia constituted 1.0% of the prey and the remaining 2.8% were isopods. Fish fry and sub-adult Decapoda Natantia were found in nineteen and three stomachs respectively, belonging to the first and second predator size classes, caught at the end of October and in winter samples. By weight, fish represented 99.95% of total prey biomass. Partially or well-digested prey, assessed as unidentified fish, accounted for 30% of the total number of prey items; unidentified fish fry made up 16.7%. Among the remaining prey, 20.6% belonged to

the Gobiidae, 7.0% to the Centracanthidae, and 5.1% to the Labridae. Among the gobiids some specimens of *Aphia minuta* were identified. All *Coris julis* specimens were found to be females. Prey biomass was dominated by Sparidae and Centracanthidae, with 29.4% and 28.3% of the biomass, respectively, then Mullidae (15.6%) (Table 1, Fig. 2). Among the last named families, the most abundant prey species for *F. commersonii* were *Spicara smaris*, *Boobs boops*, and *Mullus barbatus*.

Feeding habits

The relationships between the size of the predator and the size of the prey are shown in Fig. 3. The size of the prey increased as the size of *F. commersonii* increased for all prey fish with known SL (Spearmans correlation coefficient; rs = 0.632, $P < 0.0001$, $n = 628$, Fig. 3d). This was also true for benthic (rs = 0.665, $P < 0.0001$, $n = 189$, Fig. 3a) and supra-benthic (rs = 0.701, $P < 0.0001$, $n = 182$, Fig. 3b) prey, but not for pelagic prey (rs = –0.026, $P = 0.848$, $n = 55$, Fig. 3c). The size of the benthic prey fish ranged from 7.8 to 68 mm in SL (19.6 ± 8.5 SD, $n = 192$), the supra-benthic from 10.6 to 108 mm in SL (49.4 ± 18.8 SD, $n = 182$), the pelagic prey fish from 29 to 73 mm in SL (42.6 ± 8.1 SD, $n = 56$), and the size of all prey fish ranged from 5 to 108 mm (35 ± 20 SD, $n = 628$). An evident relationship was observed between predator size class and prey size (Table 2).

The division of prey taxa according to habitat made it possible to distinguish a change in foraging behaviour of *F. commersonii* related to its body size. All three size classes fed on supra-benthic fishes. The smaller cornetfish also fed on benthic fish species whereas the larger cornetfish extended their diet to include pelagic fish species. The results also indicated that the second class was able to catch prey fish from all three habitats, although supra-benthic prey dominated (Figs. 3a–3c).

Length–weight relationship

Length–weight relationships for all samples and for samples caught in different months showed a good fit to the exponential curve, with R^2 greater

Table 1 Overall number and weight percentage composition of prey items found in the stomachs of 207 *F. commersonii* specimens sampled in fall and winter[a]

Prey category	N	% N	W	% W	W (calc.)	% W (calc.)
Crustacea	34	3.83	0.33	0.05	0.33	0.05
Isopoda-Cymothoidae	25	2.82				
Decapoda-Natantia (sub-adult)	9	1.01				
Teleostei	854	96.17	623.13	99.95	649.16	99.95
Unidentified fish	266	29.95	54.70	8.77	54.70	8.42
Fish fry (unidentified)	148	16.67	7.40	1.19	7.40	1.14
Identified fish	440	49.55	561.03	89.99	588.45	90.60
Benthic fishes	*192*	*21.62*	*33.66*	*5.40*	*36.57*	*5.63*
Gobiidae	183	20.61	28.82	4.62	28.82	4.44
Juvenile gobiids	152	17.12	13.38	2.15	13.38	2.06
Synodontidae (*Synodus saurus*)	9	1.01	4.84	0.78	7.75	1.19
Supra-benthic fishes	*192*	*21.63*	*485.38*	*77.85*	*510.53*	*78.59*
Centracanthidae (*Spicara smaris*)	62	6.98	167.94	26.94	183.76	28.29
Labridae	45	5.07	19.19	3.08	17.63	2.71
Coris julis	20	2.25	8.77	1.41	7.81	1.20
Thalassoma pavo	1	0.11	1.12	0.18	1.12	0.17
Symphodus sp.	4	0.45	2.49	0.40	2.49	0.38
Symphodus doderleinii	1	0.11	0.20	0.03	0.12	0.02
Mullidae	38	4.28	97.27	15.60	101.27	15.59
Mullus barbatus	19	2.14	67.74	10.87	71.46	11.00
Mullus surmuletus	4	0.45	12.85	2.06	2.60	2.10
Sparidae	33	3.72	179.11	28.73	191.22	29.44
Boops boops	25	2.82	166.54	26.71	176.10	27.11
Oblada melanura	3	0.34	3.03	0.49	5.33	0.82
Diplodus annularis	3	0.34	4.31	0.69	5.16	0.79
Diplodus vulgaris	1	0.11	1.77	0.28	1.38	0.21
Pagellus bogaraveo	1	0.11	3.24	0.52	3.24	0.50
Pomacentridae (*Chromis chromis*)	11	1.24	14.98	2.40	12.02	1.85
Scaridae (*Sparisoma cretense*)	2	0.23	5.08	0.81	2.82	0.43
Siganidae (*Siganus rivulatus*)	1	0.11	1.81	0.29	1.81	0.28
Pelagic fishes	*56*	*6.30*	*41.99*	*6.74*	*41.35*	*6.37*
Atherinidae	32	3.60	33.47	5.37	35.50	5.47
Atherina hepsetus	21	2.36	21.54	3.46	22.17	3.41
Engraulidae (*Engraulis encrasicolus*)	24	2.70	8.52	1.37	5.85	0.90

[a] N, total number; % N, percentage by number; W, weight (g); % W, percentage by weight; W calc., weight calculated from length–weight relationships; % W calc., percentage by weight calculated from length–weight relationships)

than 0.993 for all four cases (Table 3). The value of b in the four relationships was >3. It was 3.377 for all individuals (September to March), 3.369 in September and October, 3.409 in December, and 3.534 in February and March. The value of a varied. It was 0.000147 for all individuals (September to March), 0.000154 for September and October, 0.000132 for December, and 0.000073 for February and March.

Temporal variation

Mean condition factors for the bluespotted cornetfish for the two seasons examined, autumn and winter, were estimated to be 0.000150 and 0.000135 respectively. There was a significant difference between the condition factors in the two seasons considered (ANOVA, $n = 37$, $P < 0.01$).

The ratio K was slightly higher than unity in autumn (K: 1.02 ± 0.10 SD) whereas in winter it was lower (K: 0.92 ± 0.08 SD).

Discussion

The diet of the bluespotted cornetfish *F. commersonii*, which recently invaded Rhodes, was found to comprise almost entirely fish (96% by

Fig. 2 Percentage by number (% N) and by calculated weight (% W calc.) of fish prey families found in the stomachs of *F. commersonii* sampled in fall and winter
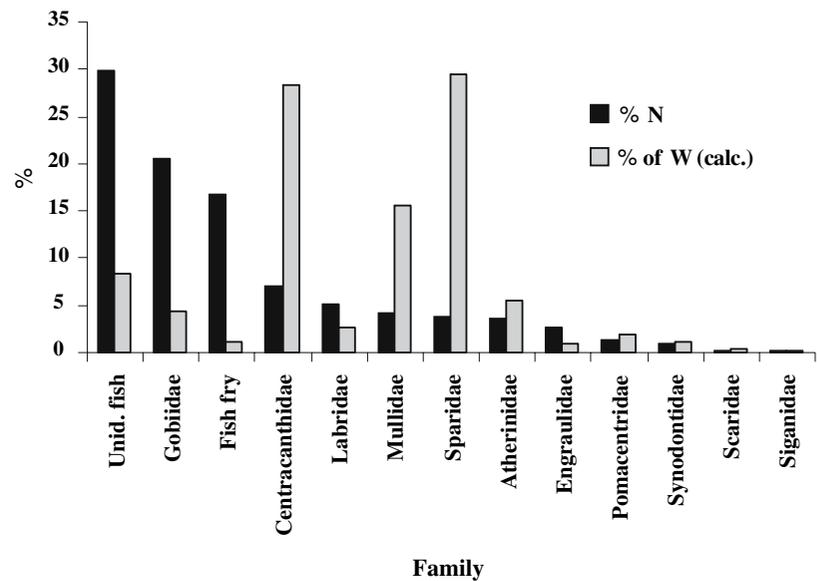
number and 99.95% by weight) according to analysis of the stomach contents of specimens collected between September 2004 and March 2005. Biological invasions have the potential to change an ecosystem dramatically, by effecting its processes, composition, and food-web interactions (e.g. Grozholz et al. 2000). The success and impact of an invasive species may, however, be hard to predict given the high complexity of marine food-webs. In fresh-water systems, in which the impacts of introduced species have been more extensively studied, "empirical rules" have been proposed as an aid to understanding biological invasions (Moyle and Light 1996). Among these empirical rules, the ability of piscivorous invaders to alter fish assemblages with cascading effects through the ecosystem is particularly well documented (Carpenter et al. 1985; Goldschimdt et al. 1993). Marine ecosystems are, however, open, complex, and commonly subject to a multitude of anthropogenic stressors, which makes it hard to link changes in ecosystem structure to the appearance of a specific species. In addition, study of the interactions between large and highly mobile predators and prey are rarely amenable to field experiments. In these circumstances, diet descriptions are an important and feasible first step in evaluating the potential impact of an invasive piscivor.

Identified prey fish belonged to eleven teleost families commonly found in trawl catches in the area (Corsini and Economidis 1999; Corsini et al. 2002). The variety of prey families corresponds to results of Takeuchi et al. (2002), who recognized ten fish families in the diet of a conspecific population of cornetfish in shallow reef waters of South Japan. Four prey-fish families (Gobiidae, Labridae, Mullidae and Scaridae) are also present among the prey reef fish of *F. commersonii* in Japanese reef habitats (Takeuchi et al. 2002), confirming that many colonizers of Mediterranean coastal waters retain their basic feeding habits (Golani 1993b), at least in the early stage of their expansion into a new habitat.

More than 70% by weight of the diet of *F. commersonii* is made up of native species of economic value—*S. smaris*, *B. boops* and mullid spp. (Vidalis and Tsimenidis 1996; Tserpes et al. 1999; Machias et al. 2001; Labropoulou et al. 2003). The first two species exceed 90% of the total fish catch weight around Rhodes (G. Kondilatos, personal observation).

Although the area under study has a high diversity of Erythrean species (Corsini et al. 2005, 2006), few are commonly captured and have economic value. Among the species emerging as commercially important are the siganids (*Siganus luridus* and *S. rivulatus*) and school-forming
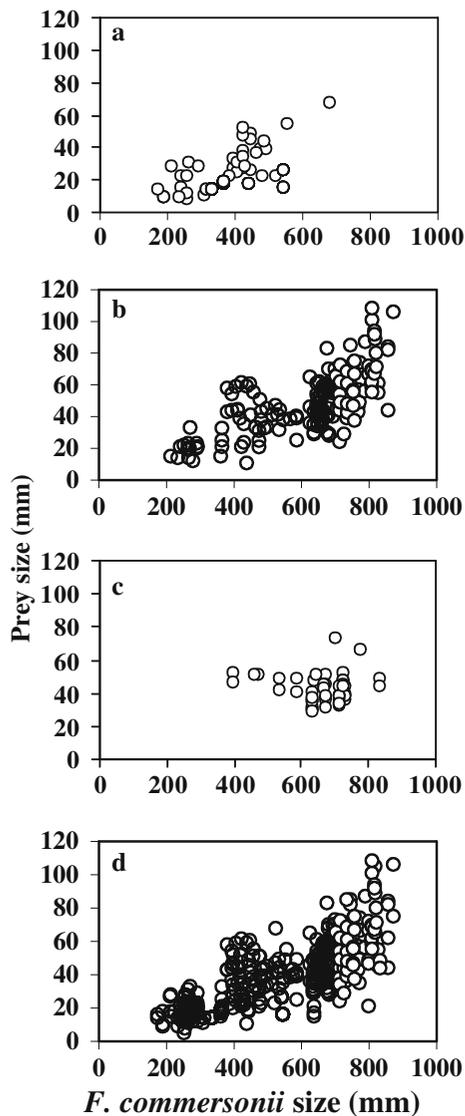
Fig. 3 Relationships between *F. commersonii* size and prey size, according to prey habitat (**a**: benthic, **b**: supra-benthic, **c**: pelagic) and for all fish prey with known SL (**d**)

Table 2 Mean, standard deviation (SD), and range of prey sizes (mm) for predator size classes

Predator size class	*n*	Prey size	
		Mean ± SD	Range
1	52	15.72 ± 4.35	5–33
2	116	29.09 ± 15.91	7–83
3	39	56.71 ± 17.61	21–108

n is the number of predators

species of the Sphyraenidae (especially *Sphyraena chrysotaenia*) (Corsini and Economidis 1999). *Etrumeus teres* is also rapidly expanding its distribution and increasing its population size in the South Aegean waters of Greece (Lekkas and Kallianiotis 2005). Other Erythrean fishes established in the region, for example *F. commersonii*, have not yet become economically important. Among the commercially important invasive species, only a single specimen of *S. rivulatus* was identified in the stomachs of the blue cornetfish. There is, however, the possibility that Erythrean aliens are present among the unidentified fishes or fish fry (Table 1). Most of the identified prey fish have an elongated body shape (low depth in relation to length) that is in accordance with the elongated mouth shape of *F. commersonii*. The abundance of *S. rivulatus*, *S. luridus*, and other fish with high body depth (e.g. *D. vulgaris*) in the area is, moreover, lower than the abundance of *S. smaris* and *B. boops*, which have an elongated body shape. *F. commersonii* preys mainly on native fish, including commercially important species, and the low prevalence of other Erythrean aliens in its diet may be related to the different body shape and abundance of native and alien species. The resulting feeding habits do not furnish information ''concerning the role of lessepsian migrants in facilitating the way for other colonizers to invade the Levant and establish self-sustaining populations'' (Golani 1993b).

Occasionally ''invaders eat invaders'' when the native community structure has already been disrupted before the invasion of the species under study (Matern and Brown 2005). The ecological condition of the benthic ecosystem around Rhodes was recently classified as good to very good (A. Pancucci-Papadopoulou, personal communication) but the fish assemblage has been subject to a long history of fishery and invasions and baseline data on historical fish assemblages are generally lacking.

The percentage by number (% N) and by weight (% W) composition of each prey taxon gave information about its contribution to the diet. To evaluate the importance of each prey taxon, consideration both by number and by weight percentage composition is required.

Table 3 Terms of the length–weight relationship $W = a\,SL^b$ for *F. commersonii*[a]

Month	a	b	R^2	n
September to March	0.000147	3.377138	0.9945	245
September–October	0.000154	3.369466	0.9956	152
December	0.000132	3.409650	0.9966	56
February–March	0.000073	3.534268	0.9940	37

[a] W is the weight (g); SL is the standard length (cm); a is the intercept of the relationship; b is the slope of the relationship; R^2 is the coefficient of determination

According to Bowen (1983), if the investigation is performed to determine the impact of the predator on prey population dynamics, the percentage by number would be the best indicator. If the purpose of the investigation is to measure the contribution of a particular prey type to the consumer's nutrition then the percentage by weight would be the appropriate indicator. In this study, fish fry by numbers were shown to be an important component of the *F. commersonii* diet. Benthic (almost exclusively gobiids) and supra-benthic fishes (from seven families) contributed to the diet with the same numerical abundance (21.6 %), indicating that cornetfish has the potential to be an important predator on these groups. Supra-benthic prey species clearly dominated the diet by weight (78.6%), however, suggesting supra-benthic species are of greatest importance in terms of their contribution to the metabolic demands of the cornetfish.

Similarly to results obtained for the Japan population of *F. commersonii* (Takeuchi et al. 2002), as the size of the Mediterranean *F. commersonii* increased prey size also increased for the groups "all prey", benthic and supra-benthic prey, whereas no correlation was found for pelagic prey. Supra-benthic fish also occurred in all three predator length classes, as did the group "reef fishes" in the Japanese blue cornetfish population. It seems that smaller individuals foraged near the substratum whereas larger individuals seemed to feed also on prey living in the water column.

Small cornetfish individuals (<175 mm) were not found and their absence can be attributed to the sampling period, limited to the months between September and March, the possibility that smaller individuals may use other habitats, and gear selectivity (mesh size). The length–weight relationship for *F. commersonii* as

obtained from 245 specimens nevertheless gives the first information on *a* and *b* for this colonizer in the Mediterranean region and may be useful for interregional comparisons of life histories of the invader species (Stergiou and Moutopoulos 2001; Moutopoulos and Stergiou 2002; Taskavak and Bilecenoglu 2001). It also enables estimation of the condition of the fish and, when the length is known, the biomass.

Condition factor is a good indicator of the physiological state of the fish, which is related to its welfare, and can be obtained from the length–weight relationship (Lizama and Ambrosio 2002). The condition factor for *F. commersonii* showed there were significant differences between the two seasons examined (autumn and winter). The observed weight was near that expected ($K = 1$) in autumn, whereas in winter it was clearly lower. Condition factor is directly related to the weight of the fish and many factors, for example reproduction period and storage of fats, may affect its weight.

Trawling in Greek waters is banned during the summer, 1 April to 30 September (Machias et al. 2001), and specimens for stomach analyses could not, therefore, easily be obtained all year round. Even with the limitation that seasonal variation in diet was only considered for half a year (September to March), the feeding behaviour and preferences obtained still indicate the blue cornetfish may have an economic and ecological impact in the Mediterranean Sea, because it mainly feeds on the most abundant and commercially important native fish present. Most of the fish fry and decapod prey were found in specimens caught during winter, when the number of empty stomachs was largest. It is also likely that the presence of all size classes of *F. commersonii* near the bottom results in high consumption (complementary or not, depending on size and/or

season) of small fish, which hatch and grow in this habitat and contribute to the diversity of the benthic community, particularly in *Posidonia oceanica* meadows. *F. commersonii* could also have the potential to become economically important in the catches of the commercial fishery, much as the siganids have.

This is the first study to focus quantitatively on the feeding ecology of *F. commersonii* in the Mediterranean Sea and the detailed diet described here confirms the classification of this species among the top predators of the Hellenic seas (Stergiou and Karpouzi 2005), at the same trophic level (4.50) as *Dentex dentex*, *Epinephelus marginatus*, *Euthynnus alletteratus*, and *Sarda sarda*) (Stergiou and Karpouzi 2002). The westward records of *F. commersonii* show its rapid establishment in new areas and its potential to become an important species of the Mediterranean Sea, thus indicating a need for further studies of its life history, and other aspects of its ecology not covered in this study.

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