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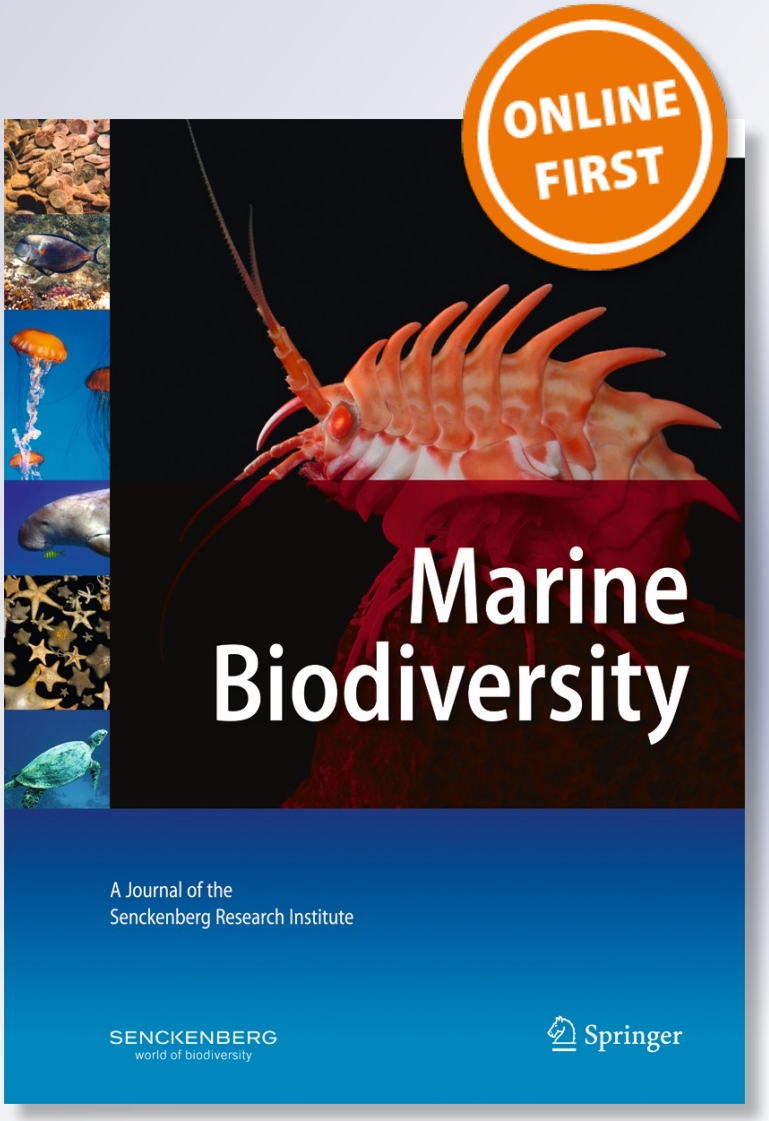

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SHORT COMMUNICATION

First record from Sicily of the Adriatic dwarf goby, *Knipowitschia panizzae* (Osteichthyes, Gobiidae), a threatened species or a threat for conservation?

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Abstract The Mediterranean endemic *Knipowitschia panizzae* (Verga 1841) has been recorded in the protected area of "Capo Peloro Lagoon", north-eastern Sicily, and 12 specimens have been collected. The record represents the first finding of the Adriatic dwarf goby in Sicily and the most southern one in the Mediterranean Sea. This record significantly extends the known distribution of *K. panizzae* and shows the invasive potential of this species in vulnerable transitional water habitats, making *K. panizzae* at the same time in different localities a possible threat for conservation and threatened species.

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Keywords Mediterranean · Conservation · Transitional waters · Introduced species · Gobiidae

Introduction

Knipowitschia panizzae (Verga 1841) is an endemic Adriatic teleost belonging to the family Gobiidae (Pizzolon et al. 2008). It is an euryhaline small-sized species found in fresh and brackish waters. A detailed morphological study of the Adriatic populations of euryhaline species of *Knipowitschia* was published by Kovačić and Pallaoro (2003). It is expected that all Adriatic euryhaline *Knipowitschia* belong to *K. panizzae* and that *K. caucasica*, the widespread species present in the Aegean Sea, the Black Sea and Caspian Sea, is a complex of several species (Kottelat and Freyhof 2007). *K. panizzae* is endemic in the northern Adriatic lagoons and estuaries and in eastern Adriatic transitional waters, but it is also present in other areas. The records in Lake Trasimeno and coastal lagoons of the Tyrrhenian coasts should be considered as accidental introductions (Bianco 1989; Miller 2004), while is not proved whether *K. panizzae* is native or introduced in south-east Italian lagoons (Fig. 1). The last records in continental areas have been documented by a few populations introduced from Bolsena Lake, Italy (Zerunian and Zerunian 1990) to Maremma Regional Park, Italy (Marcelli et al. 2012a; Marcelli et al. 2012b). The species is listed in Appendix III of the Bern Convention and in Annex II of the European Union Habitat Directive.

Materials and methods

Specimens of *Knipowitschia panizzae* have been recorded in the framework of the PRA program: "Settlement

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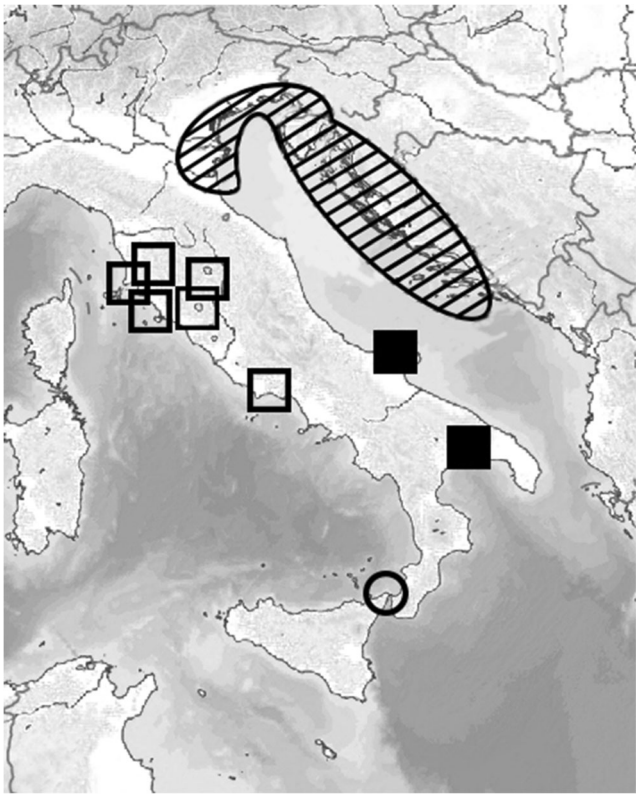

Fig. 1 Mediterranean distribution of *Knipowitschia panizzae* showing: native area (*diagonal hatching*), possibly introduced (*filled squares*), introduced (*open squares*) and present record (*open circle*)

dynamics and colonization of allochthonous assemblages in the Capo Peloro Lagoon". The Lagoon, located in north-eastern Sicily (central Mediterranean), is a protected transitional environment formed by two interconnected basins, Faro lake and Ganzirri lake, each of them communicating with the Strait of Messina throughout a proper canal. In May 2015, during a monthly monitoring, *K. panizzae* was first observed in the Ganzirri canal. The recorded specimens were photographed in situ using a Canon G16 camera in order to document live coloration and small-scale habitat characteristics. Contextually, the main hydrological parameters were recorded. A widest area of the lagoon and nearby coastal waters were examined by snorkeling in order to circumscribe the settlement area of the newly recorded species.

One individual, handily captured, was preserved in 95 % ethanol to confirm the preliminary field determination in detailed laboratory examination. Morphometric methods follow Miller (1988) and Kovačić and Šanda (2007). Meristic abbreviations: A, anal fin; C, caudal fin; D1, first dorsal fin; D2, second dorsal fin; P, pectoral fin; V, pelvic disc; LL, scales in lateral series; TR, scales in transverse series; PD, predorsal scales. Meristic methods: TR is counted from the anterior origin of the anal fin obliquely upwards and rearwards to the base of D2; LL from the axilla along the lateral midline, including the scales over the origin of C; in D2 and A counts, the last bifid ray is counted as one. Terminology regarding the lateral-line system follows Kovačić and Šanda (2007) based on Sanzo (1911). The material was stained in 2 % solution of Cyanine Blue in distilled water by a reversible staining method (Saruwatari et al. 1997) for positive confirmation of data on scales and the cephalic sensory systems. The specimen used for morphological study is a female, 34.1 + 7.7 mm (PMR VP3520) (Fig. 2), collected in the "Capo Peloro Lagoon", north-eastern Sicily, Italy, 38°15′38.45″N, 15°37′38.92″E, 9 June 2015 (coll. A. Costagliola), and deposited in the Natural History Museum Rijeka, Croatia (PMR).

Results

Material

Generic identification The following combinations of characters identify the material as a species belonging to *Knipowitschia* genus among European marine and freshwater gobiid species: (1) suborbital row *a* of sensory papillae present; (2) pelvic disc with anterior transverse membrane; (3) cheek with several suborbital transverse rows of sensory papillae; (4) anterior oculoscapular canal ends in interorbit, with paired pores λ, or at doubled pore κ (*K. goerneri*), or head canals absent; (*5) no perianal organ; and (6) oculoscapular row *tra* of sensory papillae not reaching close to suborbital row *b*.

Species diagnosis The genus *Knipowitschia* contains 17 species. *Knipowitschia panizzae* does not have apomorphies and can be identified within the genus only by the combination of characters that are not unique but still useful to distinguish the species from most or some of the other congeners. The present specimen from Sicily differs morphologically from five freshwater *Knipowitschia* species, including *K. milleri* (the others

Fig. 2 Preserved female *Knipowitschia panizzae*, 34.1 + 7.7 mm, PMR VP3520x, "Capo Peloro Lagoon", north-eastern Sicily, Italy, 9 June 2015 (photo M. Kovačić)

being *K. croatica*, *K. ephesi*, *K. montenegrina* and *K. punctatissima*), in having head canals. It is separated from another six *Knipowitschia* species (*K. byblisia*, *K. goerneri*, *K. mermere*, *K. mrakovcici*, *K. radovici*, *K. thessala*) (all of them, except *K. byblisia*, freshwater species) in having a scaled base of D2. The specimen from Sicily shares a combination of more or less unreduced anterior oculoscapular and preopercular head canals and more or less well-developed squamation with six euryhaline species of *Knipowitschia*. It could most easily be distinguished from three Ponto-Caspian species by the absence of pore ß (from *K. iljini*), and suborbital row *a* ending below thepupil (from *K. cameliae* and *K. longecaudata*) (Miller 2004). The Sicily sample mostly resembles the three species of euryhaline *Knipowitschia* present in the Mediterranean: the Adriatic *K. panizzae*, the Anatolian Aegean *K. caunosi* and the widespread *K. caucasica*. The Anatolian Aegean *K. caunosi* was only recently described (Ahnelt 2011), known only from Lake Köycegiz on the Aegean coast of Turkey. *K. panizzae* differs from *K. caunosi* by presence of anterior preorbital row s^3, the presence of oculoscapular row *y*, and the shorter length of oculoscapular row *trp*, not reaching close to row *m*. The most detailed and accurate description of *K. caucasica* was made on the population from the Aegean basin (Economidis and Miller 1990), which is also the closest *K. caucasica* population to the *K. panizzae* distribution and the present locality on Sicily. Morphological differences between *K. panizzae*, including the Sicily sample (Kovačić and Pallaoro 2003), and published data of *K. caucasica* from the Aegean basin are in the scales (scales in transverse series 7–9 (8 in the present specimen) vs. 9–10), fins (anterior membrane in midline 1/2 V I length vs. 2/3–-3/4 V I length) and morphometrics (head width larger and pectoral fin length longer in *K. panizzae*).

Table 1 Morphometrics of female specimen of *K. panizzae* from "Capo Peloro Lagoon", north-eastern Sicily, Italy

Parameters	Values
Standard length (mm)	33.9
% of standard length:	
Head length	28.6
Head width	18.3
Distance from snout to origin of first dorsal fin	39.8
Distance from snout to origin of second dorsal fin	59.0
Distance from snout to vertical of anus	55.5
Distance from snout to vertical of anal fin origin	59.6
Distance from snout to vertical of pelvic fin origin	30.1
Caudal peduncle length	27.4
First dorsal fin base	8.6
Second dorsal fin base	14.5
Anal fin base	12.1
Caudal fin length	22.8
Pectoral fin length	23.9
Pelvic fin length	23.9
Body depth at pelvic fin origin	19.8
Body depth at anal fin origin	15.6
Body width at anal fin origin	9.7
Caudal peduncle depth	8.3
Distance from pelvic fin origin to anus	24.8
% of caudal peduncle:	
Caudal peduncle depth	30.1 %
% of head length	
Snout length	24.7 %
Eye diameter	21.6
Postorbital length	57.7
Cheek depth	16.5
Head width	63.9
% of eye diameter	
Interorbital width	71.4 %
% of pelvic origin to anus	
Pelvic fin length	96.4 %

Description Body proportions are given in Table 1. Body moderately elongate, anteriorly robust with slender and laterally compressed caudal peduncle. Head large and moderately depressed, subhorizontal in dorsal profile. Snout oblique, eyes dorsolateral and ending above dorsal profile. Anterior nostril short, tubular, erect, without process from rim, posterior nostril pore-like, near orbit. Mouth oblique, posterior angle of jaws below between anterior edge of eye and anterior edge of pupil. Branchiostegal membrane attached to entire lateral margin of isthmus, ending nearly pectoral fin base. Fins: D1 VI; D2 I/8; A I/8; C 13 branched rays, 14 segmented rays; P 16 (both sides), V I/5 + 5/I. Fin-bases and lengths in proportion to standard body length are given in Table 1. D1 spines ending much before D2 I. D1 and D2 bases well separated. D2 commences over vertical of anterior beginning of urogenital papilla, with last ray over vertical of penultimate A ray. A commences below second segmented ray of D2. C rounded. P extends back to below anterior beginning of interdorsal space. V rounded, endings lightly before anus, anterior membrane in midline 1/2 V I length, with slightly crenate, almost straight rear edge. Scales: body covered with ctenoid scales, along lateral midline to axilla and around caudal peduncle. Head, breast, abdomen and anterior part of back naked. Back naked below D1, scales beginning anteriorly from third ray of D2. Scaleless area below D1 with low rear edge beginning from behind upper part of axilla, going back and upwards, and ending at third to

fifth rays of D2. Region around anus naked, A base scaled. Scales in lateral series 34 (both sides), in transverse series 8 (both sides). Lateral line system: head with anterior and posterior oculoscapular, and preopercular canals, with pores λ, κ, α, ρ, ρ^1, ρ^2, and γ, ε respectively. Rows and number of sensory papillae (the numbers counted on the left side, presented in parentheses): (I) *preorbital*: snout with three rows in median preorbital series: internal row *r* (7); outer row *s* (4); short anterior row s^3 as three clustered papillae above upper lip. Lateral series *c* in three parts: superior c^2 scattered below posterior nostril (3); middle c^1 (3) horizontal, anteriorly beginning behind anterior nostril; single inferior longitudinal row $c_{1,2}$ (7) above lip. (II) *suborbital*: row *a* reaching anteriorly to below anterior edge of pupil, consisting of 9 longitudinally arranged larger papillae with single transverse proliferation, transverse row *atp* (3). Longitudinal row *b* (12) reaching anteriorly to below rear border of eye. Seven transverse row *c*: *c1* (3), *c2* (4), *c3* (5), *c4* (4), *c5* (4), *c6* (2), in front of anterior beginning of row *b*, and *cp* (13) from below row *b* downwards to below level of row *d*. Longitudinal row *d* with supralabial part (8) and posterior part with scattered papillae (13), not reaching posteriorly row *cp*. (III) *preoperculo-mandibular*: external row *e* divided into anterior (e^1: 25), and posterior sections (e^2: 26); as well as internal row *i* (i^1: 18, i^2: 18); mental row *f* (3). (IV) *oculoscapular*: anterior transverse series *tra* (3) behind pore α; anterior longitudinal row x^1 divided by posterior transverse row, *trp* (10), in anterior section (10), and posterior section (4); posterior longitudinal row x^2 present (8); row *u* and row *q* not visible; row *z* (8) present; row *y* present as three papillae below row x^2. Axillary row as^1 (11), as^2 (8), as^3 (11), la^1 (5) and la^2 (5) present. (V) *opercular*: transverse row *ot* (22); superior longitudinal row *os* (14); and inferior longitudinal row *oi* (15). (VI) *anterior dorsal*: transversal row *n* (17) long, starting downwards above pore α and row *tra*; longitudinal row *g* (8); *m* (4) and *h* (8) present; row *o* absent. Coloration: general live color (Fig. 3) is pale fawn, reticulate posteriorly, with conspicuous pale saddles across back; black chin spot; female with larger yellow belly patches produced ventrally and head and breast dark. Preserved female (Fig. 2): body yellowish and, except the underside, covered with numerous melanophores, variably and irregularly mottled with hardly recognizable patterns. The five pale dorsal saddles are poorly visible: at nape opposite opercle, origin of first dorsal fin, interdorsal space and origin of second dorsal fin, posterior end of second dorsal fin and posterior part of caudal peduncle. Several darker blotches are hardly recognizable along the lateral midline. Head pigmented in upper part, underside mostly whitish, poorly distinguished preorbital bars extend as intensive dark blotch on the chin forming Y shape. The first dorsal fin with broad dark band in middle third, and rare pigmentation at base and at fin tips. Second dorsal fin rarely pigmented without recognizable pattern. Caudal fin with melanopohores forming poorly visible vertical bands. Pectoral fin with dark blotch on the upper rays origin and rarely scattered melanophores on the rest of the upper part of fin. Pelvic fin whitish.

Ecology Since the first record in the Capo Peloro Lagoon (May, 5, 2015) up to the last survey (June, 16, 2015), 12 specimens were found in the middle part of the Ganzirri canal (Fig. 4). On average, 3 ± 1 specimens per sampling were recorded. The finding area, less than 450 m^2 surface area, is extremely circumscribed since specimens have been exclusively observed in the inner part of the canal. The canal, which is characterized by shallow waters (0.5–1.5 m depth), with low, semidiurnal, tidal oscillations (±40 cm), is subjected to a remarkable water flux that reaches speeds of 2 m/s. Water temperature ranges from 19 to 24 °C; salinity from 36.0 to 36.8 psu. All specimens were found near the artificial rocky banks, lying on the bottom (Fig. 3a) or swimming approximately 50 cm above the canal bed (Fig. 3b). The substrate consisted of coarse sand and shell debris patchily covered by green and red algae. Only isolated specimens have been recorded.

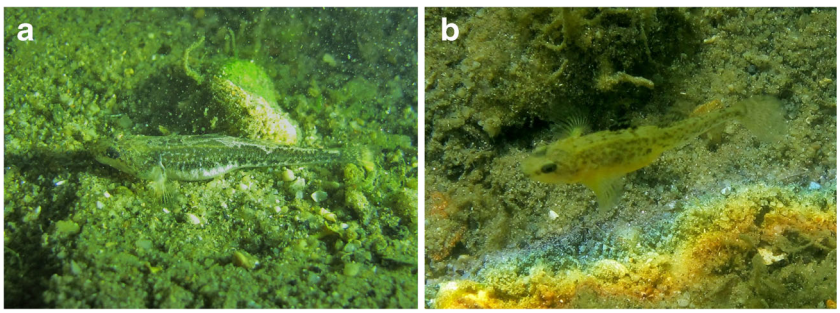

Fig. 3 Male (**a**) and female (**b**) *Knipowitschia panizzae* specimens photographed in situ

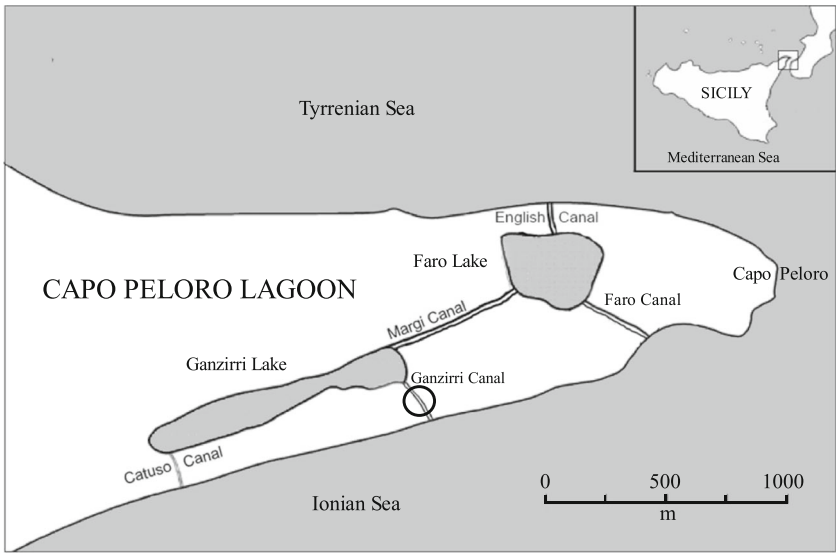

Fig. 4 *Circle* indicates the *K. panizzae* sampling site

Discussion

The identification of the Capo Peloro Lagoon *Knipowitschia* as *K. panizzae* was based on the best available, i.e. published, data on the morphology of Adriatic *K. panizzae* and the morphologically closest *K. caucasica* (Economidis and Miller 1990; Kovačić and Pallaoro 2003). It also matches the native distribution and recent extensions in geographic range of these species where the most western population of *K. caucasica* in Aegean Sea is divided by a gap from the most eastern populations of *K. panizzae* (Kottelat and Freyhof 2007). The present morphological description of *K. panizzae* is the only published morphological work for *K. panizzae* in addition to Kovačić and Pallaoro (2003) which is detailed enough to be useful to distinguish closely related *Knipowitschia* species. The observed yellow patch on the belly of *K. panizzae* females demonstrated that the female was ready to spawn (Massironi et al. 2005). *K. panizzae* is a species with an annual cycle, which displays an r-strategy (Nonnis Marzano and Gandolfi 2001). The reproductive period extends from early spring to late August; the adults, after mating, die and only the recruits survive (Gandolfi 1973). The observed reproductive phase explains the finding of isolated specimens, due to female aggressiveness and potential cannibalism (Nonnis Marzano and Gandolfi 2001).

The *K. panizzae* from the Capo Peloro Lagoon is the first finding of this species in Sicily and its most southern record. The species was not cited in the report of Cavaliere (1967) on the Capo Peloro ichthyofauna, and during the current monitoring program has not been found prior to May 2015, testifying to the still ongoing translocations of this species. The record significantly extends the known distribution of *K. panizzae* and turns attention to this potentially invasive species in vulnerable transitional water habitats. Such spreading, which has been suggested to be of anthropogenic origin (Bianco 1995), is in accordance with the already proved introduction of flora and other fauna into Faro lake (Manghisi et al. 2011; Giacobbe and De Matteo 2013) by mollusc farming and trade. Declines of endemic taxa and the concurrent settlement of introduced species, recently reported for molluscs (Giacobbe 2012), testify to the ecological fragility of the basin. *K. panizzae* is not regarded as globally threatened or threatened in Europe by the IUCN (Freyhof and Brooks 2011), and it was not evaluated in the regional red lists (Jardas et al. 2008) or was considered of least concern, i.e. not threatened in the Italian Red List (Rondinini et al. 2013). However, losses and degradation of transitional water habitats threatens the species survival at localities within its native Adriatic distribution. Therefore, the species has been proclaimed to be endangered and protected in Italy and Croatia and it is also listed in Appendix III of the Bern Convention and in Annex II of the European Union Habitat Directive. *K. panizzae* is a species with r-selection reproductive strategy and rapid growth, and it is an opportunistic generalist predator (Nonnis Marzano and Gandolfi 2001; Miller 2004). Species with these characteristics could easily become invasive species in fragile ecosystems. The euryhaline gobies, like *Neogobius* spp., have already proved themselves as very successful invasive species thanks to their tolerance to a wide range of environmental factors, broad diet, aggressive behavior and reproductive potential (Corkum et al. 2004). The recent settlement of such kinds of species in the Capo Peloro Lagoon show a rarely encountered contradictory position of a species, which is threatened and could be extinct in habitats within its natural range of distribution due to habitat degradation and destruction. but elsewhere represents a potential

invasive species, which could be involved in the biotic homogenization process of the Mediterranean by human-mediated ecological contaminations (Bianchi et al. 2012; Garzón-Machado et al. 2012). The population dynamics of *K. panizzae* and its influence on the ecosystem of the Capo Peloro Lagoon should be monitored, and experience and data from there used in relation to possible further spreading of *K. panizzae* along Mediterranean lagoons.

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