

**First records of a new color pattern in the Goldblotch Grouper, *Epinephelus costae* (Steindachner, 1878) (Actinopterygii: Serranidae) and first record of leucism in the European conger, *Conger conger* (Linnaeus, 1758) (Actinopterygii: Congridae): a citizen science contribution**

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*In many fish, color patterns are striking features and can play an important role in both natural and sexual selection. Furthermore, details of color patterns are in some cases valid tools for species identification. However, fish can also show some genetic abnormalities, such as albinism and leucism. In this research, we report for the first time a new color pattern for *Epinephelus costae* (Steindachner, 1878), for which it is known an ontogenetic shift in color pattern, and the first case of leucism in *Conger conger* (Linnaeus, 1758).*

**Key words:** Mediterranean Sea; color pattern; citizen science; abnormal coloration; coastal fish species

## INTRODUCTION

*Epinephelus costae* (Steindachner, 1878) is one of the most intriguing species of the genus *Epinephelus* Bloch, 1793 as concerns the color. It is a demersal species, found in coastal waters between 1–200 m depth, more commonly at depth between 10 and 80 m, on sandy, muddy and rocky bottoms (HEEMSTRA & RANDALL, 1993; FROESE & PAULY, 2020). The maximum reported standard length for this species is of 140 cm (FROESE & PAULY, 2020). The most intriguing fea-

tures of this fish are related to the color change between juveniles and adults, a point that is well described in the reference book of HEEMSTRA & RANDALL (1993): «Juveniles less than 15 cm standard length with 3 to 5 narrow dark stripes (possibly blue in life) paralleling lateral line on dorsal part of body: 2 stripes above and 1 to 3 stripes below the lateral line. Two dark lines on head: one from the lower edge of eye to the ventral rear edge of inter-opercle, the second from dark maxillary streak to the lower edge of the preopercle. Adults are brown or greyish brown,

often with a large, distinct golden yellow blotch (vaguely defined at periphery) on body below spinous dorsal fin».

The fundamental point is that a chromatic variation takes place during the life of this proterogynic fish: the stripes of juveniles are succeeded by the yellow blotch of the adults. Now, it is precisely the discovery of this variation who led the biologists to accept unification under the name *E. costae* of phenotypes which in the past had been classified under different species because of the ignorance of such ontogenetic color pattern variation.

A decisive step in this history was marked by DODERLEIN (1882), who argued that the three presumed species namely *Serranus costae* Steindachner, 1878 (name taken from COSTA, 1850), *Serranus alexandrinus* Valenciennes, 1828, both characterized by more or less developed horizontal stripes, and *Cerna chrysothaenia* Döderlein, 1882, characterized by a yellow blotch, were the three developmental stages of a single species.

The phenomenon of the yellow blotch was later studied in more detail by two Italian scholars, BINI (1960) and, especially, TORCHIO (1963), who established three additional points:

1. The yellow blotch which can be observed in fish of a minimum total length of 35 cm;
2. In living specimens, the color changes underwater and, specifically, the horizontal stripes turn into a yellow blotch, and conversely, the yellow blotch turns into stripes in a few minutes;
3. The yellow blotch tends to disappear *post mortem*.

More recently, AGOSTINI & PURETTI (2018) developed this point arguing that: 1) the presence of the yellow blotch in *E. costae* is a reversible phenomenon not only in live specimens, but also in dead ones; 2) the blotch can appear *post mortem* also in specimens which, when alive in the sea, did not present the blotch. However, this is not the whole story.

We think that another feature concerning the color of *E. costae* should be added, one which was until now not yet reported in the scientific literature. A similar feature was largely

documented in *Epinephelus marginatus* (Lowe, 1834), especially as concerns juvenile specimens: the presence of yellow star-shaped blotches on body and head, mostly arranged in vertical series (they are at the origin the vernacular name of *Cernia stiddata* in Santa Maria di Leuca; see AGOSTINI, 2018).

The European conger, *Conger conger* (Linnaeus, 1758) is a common benthic species of rocky and sandy bottoms of the northeastern Atlantic and Mediterranean Sea, where it is the only representative of the genus. It can reach a maximum total length of 300 cm, but common sizes are of about 100–150 cm (FROESE & PAULY, 2020). It is usually found between 0–500 m depths, but it has been found at a depth of 1171 m (MYTILINEOU *et al.*, 2005). Females are larger than males (CASADEVALL *et al.*, 2017). The typical color pattern of this species consists of an almost uniform light grey to blackish body, with a whitish ventral part. Lateral line pores are white and the distal margins of the dorsal and anal fins are blackish (COSTA, 1991). Mature females undergo a deep transformation in color and morphology (i.e. an almost uniformly black body color, trapezoidal and very short pectoral fin and larger eyes) when reaching the final life stage (BATTAGLIA *et al.*, 2019).

We report the first observation of a large specimen of *C. conger* affected by leucism.

## MATERIAL AND METHODS

On 30<sup>th</sup> May 2020, two specimens of *E. costae* with a total length (TL) of about 35 and 50 cm were caught with trolling line at Alimini, Otranto (Adriatic Sea), at a depth of about 22 m (Fig. 1). Both specimens showed a curious color pattern, never described in literature so far. Another specimen of *E. costae* of about 40 cm TL with a similar color pattern was observed and photographed *in situ* on 19<sup>th</sup> May 2020 at Pellaro (Calabria, Strait of Messina), at a depth of about 20 m (Fig. 1).

On 24<sup>th</sup> September 2020, a white conger eel weighing 12.5 kg was caught NE off the Andros Island (Aegean Sea) with hand-line by a commercial fisherman at a depth of 280 m.



Fig. 1. Study area in the central (Italy) and eastern (Greece) Mediterranean Sea. Red circles indicate locations where the specimens of *Epinephelus costae* were caught (Alimini, Adriatic Sea) and photographed *in situ* (Pellaro, Strait of Messina); the yellow circle indicates the location where the white specimen of *Conger conger* was caught (Andros Island, Aegean Sea)

Unfortunately, the fish was sold at the market and further detailed analyses were not possible.

Fishermen and the underwater photographer were interviewed in order to collect additional and useful details for a better description of the records.

## RESULTS AND DISCUSSION

As in normal specimens, the background body color of the two specimens of *E. costae* collected at Alimini was dark brown on the dorsal area, and gradually lightened towards the ventral surface, becoming grayish on belly. However, we observed for the first time the presence of irregular yellow blotches, organized in four irregular slightly oblique stripes, extended from the dorsal surface up to about half height of sides. The first extended from the first three spines of the dorsal fin to the superior part of the opercle; the second one extended between the 6<sup>th</sup> and 8<sup>th</sup> dorsal spine to the height of the posterior and superior part of the pectoral fin; the third one extended from the 1–4<sup>th</sup> soft dorsal rays to about half body height on sides; the fourth one extended from the last soft rays of the dorsal fin and part of the caudal peduncle to almost the ventral part of the body. Furthermore, some irregular yellow blotches were present on the dorsal area of the head (Fig. 2a). The smaller

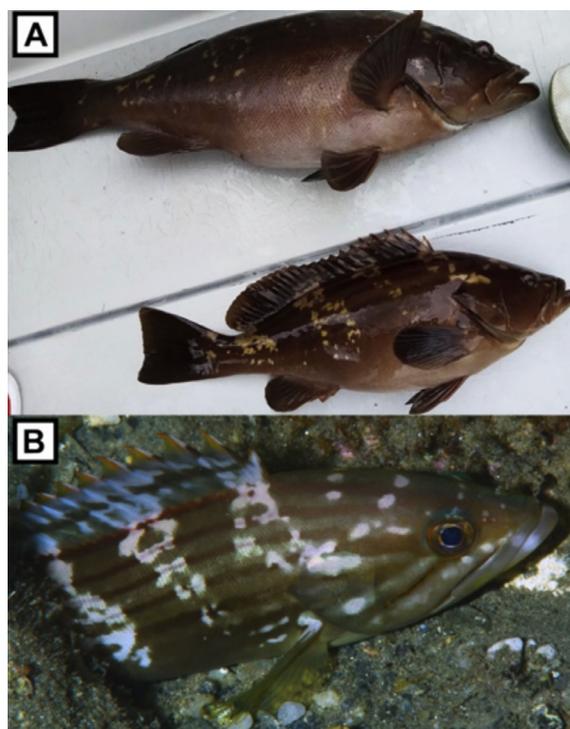


Fig. 2. The two specimens of *E. costae* collected at Alimini (Adriatic Sea) on 30<sup>th</sup> May 2020 (A) and the specimen photographed at Pellaro (Strait of Messina) on 19<sup>th</sup> May 2020 (B)

specimen showed, although not clearly visible, the typical longitudinal dark bars of the species. The specimen photographed at Pellaro was initially misidentified by the photographer as *E. marginatus* because the presence of “strange white-grayish vertical bars”, similar to those of *E. marginatus* and equal (but of different color) to those observed in the specimens of *E. costae* caught at Otranto (Fig. 2b). However, after the examination of the photos by authors, the fish was easily identified as *E. costae* because the presence of its typical longitudinal dark stripes. To the best of our knowledge, this is the first work showing this “atypical” color pattern in *E. costae*: four slightly oblique (almost vertical) blotched yellow or white-grayish bars were present on body, similarly as is commonly known in the typical color pattern of juveniles of *E. marginatus*, although they may also be present in some adult specimens. Although this particular coloration seems rare, further studies are necessary in order to assess how spread is



Fig. 3. The white specimen of *C. conger* (A) collected NE off the Andros Island (Aegean Sea) on 24<sup>th</sup> September 2020 and particular of the head (B)

this phenomenon and its relationships with size, environmental factors and/or genetics. However, a curious fact is that this characteristic was never reported in literature.

The white conger eel caught NE off the Andros Island was almost uniformly white (Fig. 3a) and with some doubts it was correctly recognized by the fisherman as an European conger, *C. conger*, considering the typical morphological features of this species. The fish was still alive when taken on board and the white color was maintained also after death. Considering that the eyes showed the normal color of *C. conger* (Fig. 3b), rather than reddish shades (typical of true albinism), and the fact that the distal part of the dorsal and anal fins was light grey in color, we are faced with a case of leucism (partial albino)

rather than albinism (VEENA *et al.*, 2011). In all the observed cases, these phenomena are generally attributed to genetic mutation (SANCHES *et al.*, 2019). To the best of our knowledge, this is the first case of leucism in *C. conger*. Furthermore, from photo, the tail of the specimen seems to be bifid, but unfortunately the fish was sold at the market and we have not been able to further investigate this other aspect. Although reported in several species of teleosts and elasmobranchs, leucism can be considered a relatively rare phenomenon. As regards the order Anguilliformes, an abnormal white anguillid eel, *Anguilla bengalensis* (Gray, 1831), was caught in the Perak River (Malaysia), and an abnormal white moray eel of the species *Muraena clepsydra* Gilbert, 1898, was caught in the Pacific Ocean (Ecuador)

(BÉAREZ, 2002; KADIR *et al.*, 2015). Although in some species the presence of albinism and leucism could reduce the survival capability due to predation, in nocturnal and benthic (or cryptic) species (as in the case of our specimen of *C. conger*) these abnormalities seem to have little influence (SAMPAIO *et al.*, 2015). Indeed, considering the weight of our specimen (>12 kg), the fish managed to survive in its environment for several years (MATIĆ-SKOKO *et al.*, 2012).

In conclusion, we report for the first time a new color pattern for *E. costae*, adding it to those already known for the species. In consideration of this, we can consider the color of this species quite variable and this new character, when present, should be taken in consideration for the identification of the species, in order to avoid misidentification with similar species during researches (e.g. visual census, fishery studies, analysis of photos/videos). As regards the

first case of leucism for *C. conger* here reported, further analysis would have been helpful to better understand which factors are responsible of such color variations in the fish, and to elaborate on the still poorly understood cases of leucism and albinism in general. We also highlight the role of citizen science in the Mediterranean Sea not only for the monitoring biodiversity and ecological changes, but also for the discover of new behavior, species association and morphochromatic traits (TIRALONGO *et al.*, 2019; TIRALONGO *et al.*, 2020).

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**Prvi zapis o novoj obojanosti kirnje zlatice, *Epinephelus costae* (Steindachner, 1878) (Actinopterygii: Serranidae) i prvi zapis o leucizmu ugora, *Conger conger* (Linnaeus, 1758) (Actinopterygii: Congridae): građanski doprinos znanosti**

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**SAŽETAK**

Kod mnogih riba obojanost ima upečatljiva obilježja i može igrati važnu ulogu kako u prirodnom tako i u spolnom odabiru. Detalji o uzorcima boja u nekim su slučajevima valjani alat za identifikaciju vrsta. Međutim, riba može pokazati i neke genetske abnormalnosti, poput albinizma i leucizma. U ovom istraživanju prvi put izvješćujemo o novoj obojanosti *Epinephelus costae* (Steindachner, 1878.) i o prvom slučaju leucizma kod ugora, *Conger conger* (Linnaeus, 1758),

**Ključne riječi:** Sredozemno more; obojanost; građanska znanost; abnormalna obojenost; obalne vrste riba

