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The First Record of Caudal Fin Deformity in the European Conger, *Conger conger* (Linnaeus, 1758) (Pisces: Anguilliformes) Collected from Northern Aegean Sea (Çandarlı Bay, Turkey)

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Abstract The first record of caudal fin-deformed wild fish, *Conger conger* (Linnaeus, 1758) from the northern Aegean Sea, Turkey was reported. The tail-deformed specimen with 370 mm Total length, 24 mm preorbital length, 14 mm eye diameter and 89 mm head length. The caudal region of the deformed specimen was completely deformed and fused, and the tail length of the abnormal fish was 33.3% when compared to the tail of the normal specimen. Possible reasons that are the cause of found abnormality such as viral, bacterial or environmental pollution are discussed. The abnormality could be considered an important indicator of environmentally induced stress since in the described area there is a significant pollution of heavy metals. The cause could be a spontaneous genetic mutation since the finding was a single specimen and not a frequent state in other fish within the studied area. Nevertheless, the present finding highlights the need for closer monitoring of the marine environment and for the identification of the specific factor that caused this abnormality.

Keywords Tail deformity · Vertebral deformity · Aegaen Sea · *Conger conger*

The history of documenting fish anomalies is long and since the sixteenth Century, when interest in this field of knowledge had started (Berra and Au 1981) a large number of studies have been made available documenting the presence of various types of anomalies in wild fishes (Boglione et al. 2006; Jawad and Hosie 2007; Jawad and ktoner 2007; Koumoundouros 2008; Jawad and Al-Mamry 2012; Jawad et al. 2016). Causes of fish deformities can be assigned to viruses (Walker and Winton 2010), bacterial infection (Balebona et al. 1993), parasites (Cunningham et al. 2005), different types of pollution (Sadler et al. 2001) and radiations (Anbumani and Mohankumar 2012). Fin anomalies, in general, are extremely well documented in both wild and reared fish (Divanach et al. 1996), but a limited number of studies concerning the caudal fin deformities have been published (Almatar and Chen 2010; Jawad 2014; Jawad and Al-Mamry 2012; Jawad et al. 2010).

The European conger, *C. conger* is a marine species prefers demersal habitat with an oceanodromous habit and lives in the depth range from the surface and down to 117 m (Riede 2004; Mytilineou et al. 2005). The distribution of this species is confined to the eastern Atlantic Ocean from Norway to the north to Senegal in the south and also found in the Mediterranean and Black Seas (Froese and Pauly 2017). It's a nocturnal predator feeds mainly on fishes, crustaceans, and cephalopods (Bauchot and Saldanha 1986; Göthel 1992), and has one reproductive cycle in its life (Maigret and Ly 1986). Individuals reaching maturity at 200 mm total length (Froese and Pauly 2017).

As far as the authors are concerned, there are no previous skeletal deformities on the record about the European conger. Therefore, the importance of this study is in the record for the first time a case of skeletal anomaly involving the posterior parts of the dorsal and anal fins in addition to the caudal fin in the European conger from Turkish waters and to describe this abnormality.

On 1st December 2015, one specimen of *C. conger* showing caudal fin deformity was caught by a bottom trawl (44 mm mesh size in cod-end) at depth of 50 m from Çandarlı Bay, Izmir (38°52′ N - 26°51′ E). A normal specimen was also

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obtained from the same fishing lot used for comparison. The specimens were fixed in 70% ethanol and deposited in the fish collection of the Ege University, Fisheries Faculty (ESFM-PIS/2015–11). The skeleton of both normal and abnormal specimens was examined by x-ray and measurements were recorded to the nearest millimeter.

The tail-deformed specimen had the following body measurements: 370 mm Total length, 24 mm preorbital length, 14 mm eye diameter and 89 mm head length, and 23.3 mm tail length. This specimen is compared to normal fish having 490 mm Total length, 14 mm preorbital length, 8 mm eye diameter, 65 mm head length, and 70 mm tail length (Fig. 1a,b). The tail length of the abnormal fish is 33.3% of the tail of the normal specimen.

Externally, the caudal fin short and the caudal fin rays were deformed. The connection with both the dorsal and the anal fins was missing due to the shortening of the caudal fin. The dorsal and the ventral sides of the body were down-elevated under the posterior part of the dorsal fin (Fig. 2). The radiograph of the abnormal specimens was compared with that of the normal (Fig. 3,a,b) and showed the following skeletal deformities; (1) the last 14 caudal vertebrae appeared to be involved in a severe vertebral deformities; (2) the subsequent caudal vertebrae showed to have the following anomalies (counting from backward to forward): V 14, with deformed centra; V13 and 12, with both deformed centra and it bent downward; V 11 & 10, coalescence and missing half of their centra; V9, compressed; and V8–1 were severely deformed so the shape of their centra is not recognizable; (3) the neural spines of these vertebrae were deformed, but those of 1–8 vertebrae were severely deformed; (4) the skeleton of the caudal fin was deformed and raised upward. No skeletal deformities were shown in the other parts of the vertebral column.

This is the first report on the caudal fin anomaly that is observed in *C. conger* taken from wild teleosts in the Turkish waters. It aimed to identify teratogenic caudal fin in the specimen of studied species and find a possible relationship between this deformity and several types of environmental disorders such as pollutants.

The present case on caudal fin deformity was incidental and no planned experiment on the impact of malnutrition and environmental parameters was performed. Hence, it was not possible to determine the exact reason for the anomaly in the juveniles of the studied species.

In spite of the presence of a large number of studies on fin anomalies worldwide, the percentage of the aberration for each fin is not available. Generally, distribution of the fin deformities might consider the second next to the vertebral column abnormalities in fish, which comprise13% of the describe malformed vertebral columns (Galvan-Magana et al. 1994). The deformities in the caudal fin can develop as a result of abnormal bending of the posterior end of the notochord during the yolk-sac stage before the development of the caudal skeleton (Koumoundouros et al. 1997). Therefore, the fish specimen examined in the present study might have been living for several years with this deformity, and this kind of malformation would not have interfered with its biological activities, such as feeding (Ribeiro-Prado et al. 2008).

In nature, there are several potential factors that cause the caudal fin deformities, among these are the effect of exposure to light and heat during reproduction (Koo and Johnston 1978) and the pollution with heavy metals (Sloof 1982). In the Aegean Sea, the variation in water temperature during the year is obvious, with the extreme low level in the summer time when temperature and salinity at their utmost levels (Souvermezoglou et al. 1999; Sunlu 2006). Such variation will lead to decrease in oxygen level, a case is known as "hypoxia" that in turn, can induce the incidence of malformations (Eva et al. 2004).

There is a high possibility that the present anomaly in the European conger was a result of pollution with trace metals. Izmir bay is reported to have a high level of pollution in trace metals (Kucuksezgin et al. 2006; Pekey 2006; Kucuksezgin et al. 2011). The trace can decrease collagen synthesis, cause a

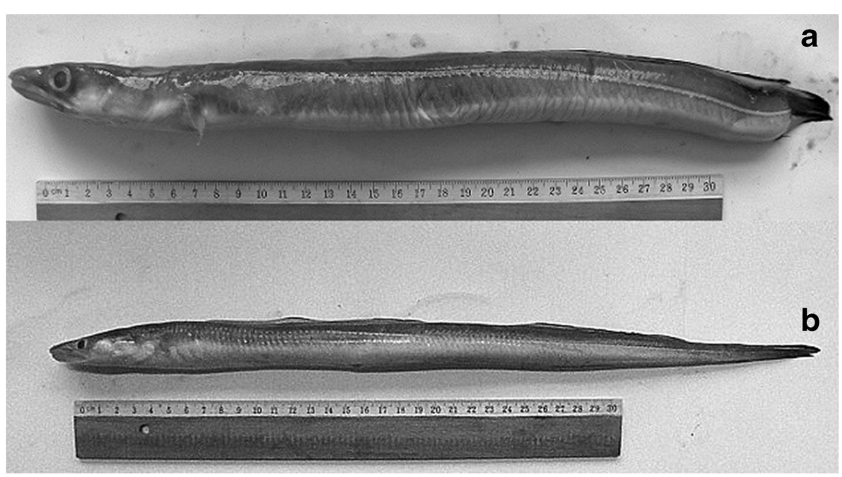

Fig. 1 Abnormal specimen of *Conger conger*, 263 mm TL

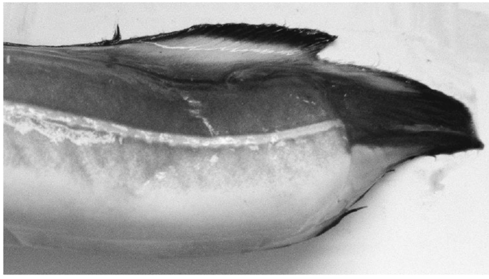

Fig. 2 Abnormal specimen of *Conger conger*, 263 mm TL, tail region

protoplasmic poison and change the integrity of the bones (Bhatnager and Hussain 1977; Luh et al. 1973; Iguchi and Sano 1982). On the other hand, the genetic factors cannot be eliminated. Tave et al. (1983) identified a dominant lethal gene responsible for the 'saddleback' phenotype in *Oreochfotnisj attfctis* (Steindaehner). Mair (1992) has concluded that a lethal mutant phenotype controlled by an autosomal recessive gene with variable expression can cause caudal deformity syndrome in *Oreochromis niloticus*, which can act upon by the natural selection agents against this recessive gene. Gjerde et al. (2005) have found that particular vertebral deformities in the Atlantic salmon are regulated by a considerable additive genetic constituent. Their work supported the results of McKay and Gjerde (1986) on the same species and Heringstad et al. 2003) on others.

To specify the ecological and behavioral impacts of a deformed caudal fin of a fish, the normal role of this fin during the swimming activity of the fish. Different fishes swim in different ways. A primary grouping marks several modes among fishes that use their body and caudal fin mainly for propulsion. The eels and eel-like fishes follow what is called the 'anguilliform' swimming type in which they undulate a large portion of their bodies (Breder 1926; Webb 1975).

Different fish species having different shapes and sizes of fins, which signaling evolutionary adaptations for either social purposes (Bischoff et al. 1985; Partridge and Endler 1987; Price et al. 1987) or swimming capacities (Beamish 1978; Yates 1983; Videler 1993). The social importance of Fin shapes and sizes are socially important in the context of sexual selection, especially in guppies (Endler 1983; Kodric-Brown 1985; Nicoletto 1991). On the other hand, the effects of different fin sizes and/or shapes on swimming capabilities within species are poorly understood (Webb 1973; Nicoletto 1991).

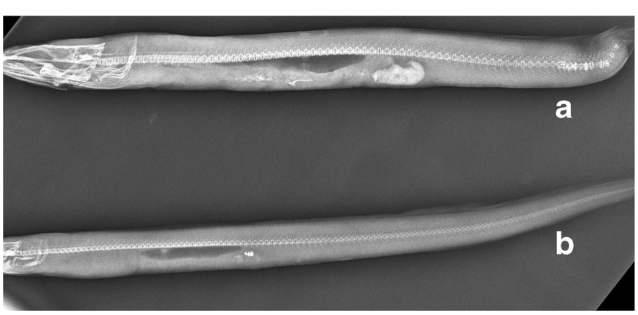

Fig. 3 Normal specimen of *Conger conger*, 490 mm TL

During the swimming activity, fin sizes and shapes play a vital role to control the swimming performance because the fins conveying to the water a large proportion of the propulsive power created by the muscles (Yates 1983; Weihs 1989; Videler 1993). A positive relationship between the amount of water accelerated and the size of the fins (Simons 1970; Long 1992; McHenry et al. 1995). Therefore, fish with high aspect ratios were characterized as fast-swimmers (Weihs 1989; Videler 1993). Normal swimming speed means the ability of fish avoid predators finding food, which enhance growth and other metabolic activities of the fish.

The anguilliform swimmers tend to be elongate with little or no narrowing at the caudal peduncle. The continuation of the dorsal and the anal fin with the caudal fin is remarkably extreme in eels (Helfman et al. 1997). They undulate from one-third to almost all of their bodies, depending on speed, often with one or more complete waves present at a time (Gillis 1998). In the hydrodynamics of the eel-like swimming, the oscillating nature of the caudal-fin lateral movements prevents the boundary-layer from growing to the thickness expected for steady-state motion. The consequence of such reduced boundary-layer thickness will be an increased drag on the caudal fin substantially enhancing the total drag of the fish. This phenomenon has been termed boundary-layer thinning (Bone, in Lighthill 1971) and has been advanced by these authors to partially explain the relatively high drag values computed for swimming fish. The substantial drag caused by the caudal fin would be reduced by removal of parts of the caudal fin (Bone, in Lighthill 1971). On another hand, Breder (1926) and Gray (1968) has noted that caudal-fin size reduction in fish swimming does not markedly impair steady, or sustained swimming performance. The effects of reducing the size of the fin are explicated in terms of redistribution of thrust-related hydrodynamic loading over the remaining portion of the tail and the body. This would change the loading on the muscle system, which is expected to affect the efficiency of muscular activity (Hill 1950). A change in muscle efficiency implies an alteration in the amount of metabolically available energy transmitted to the mechanical caudal-propeller system, and consequently a change in metabolic energy expenditure or thrust/drag relations.

The ecological impact of the deformed caudal fin or the reduction in its size can be seen clear in the fish performance, swimming behaviour and spontaneous activity. In fish performance, the outstanding swimming capability is could be an adaptation to the environment the fish living in (Laale 1977). Usually, the predatory fish are significantly larger than their prey, to avoid predation, the prey must swim or maneuver much faster and better than the predator. With individuals having a lower aspect ratio of the deformed caudal fin, a reduction in the lift to thrust will be evident in such individuals (Weihs 1989; Videler 1993). Also, the deformed caudal fin will have less number of the wave length of bending than the normal fin (Simons 1970). Still to say that the smaller the caudal fin is the less momentum transmission from the muscles to the water, which results in a reduction in swimming capability. Plaut (2000) in his study on zebrafish suggested that approximately 65% of the power transmitted to the water in individuals with normal caudal fin is derived from the tail. In fish performance and to be a fast, sustained swimmer, the fish needs to have non-deformed caudal fin. The fast and sustained movement is needed in rapid moving water environment, to escape predators and to catch a passing prey (Plaut and Gordon 1994).

Baganz et al. (1998) have shown that the size of the caudal fin affects the activity of the fish. Those with normal fins were active during their routine hours either day or night, but those with smaller or deformed fins are less active and can explore the very restricted area around their living niches.

From above discussion, it is possible to envisage that the caudal fin is playing an important role in the swimming and the activity of the fish. With the deformed fin will experience a reduction of swimming capabilities, resulting in a reduction in activity rates, may decrease the ability to gather food and make the fish more vulnerable to predation. Such costs corresponding with increased chances of sexual selection may exemplify the handicap principle (Zahavi 1977; Maynard Smith 1985).

The European conger eel is one of the most abundant predators that inhabit the continental shelf and the rocky shelf-slope areas (Xavier et al. 2010). This species feeds on crustaceans, fish and cephalopods (Cau and Manconi 1984; Morato et al. 1999; O'sullivan et al. 2004; Matić-Skoko et al. 2012; Sallami et al. 2015). Males and females differ in their food composition (Matić-Skoko et al. 2012). Such differences are related to the depth as the two sexes found at deferent depth. In some areas such as Ireland, this species is considered a specialist feeder because only a few fish species were found as prey (O'Sullivan et al. 2004). The results of Matić-Skoko et al. (2012) reflect the adaptability of the conger eel and might also partially explain the broad distribution of the species (Xavier et al. 2010). It is also found that this species is foraging close to rocky areas, where they have the ability to obtain refuge in rocks, the prey items come from the area where the fish are collected (Mytilineou et al. 2005). Such feeding habit might assist the caudal fin deformed specimen described in this study to forage only a little distance from where it lives and therefore do not need to swim far and fast to obtain food. This is possibility fits with the well-built body of the specimens suggesting that it has not been in malnutrition state.

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