

Morphology and Systematic review of Muraenidae in Iranian Museums of the Persian Gulf and Oman Sea's waters

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Abstract- Species belonged to Muraenidae family from Anguilliformes order was apart of fish fauna in the Persian Gulf and Oman Sea. These species are economically and (nourishing) ornamentally valuable. This research revising the samples taxonomy and systematic typology of Muraenidae in south coast of Iran such as: Bushehr, Chabahar, Bandar Abbas, Bandar lengeh and the rest from museums, universities and research centers in Iran (Fishing area51) form2007-2008. The whole Ichthyology valid published references in this area were considered. The result showed that: among 27 eels samples 13 samples were in Muraenidae family. *Gymnothorax undulates* was a native species in Iranian Sea zone and seven samples as: *Gymnothorax* sp, *Gymnothorax kidako*, *Gymnothorax phasmatodes*, *Gymnothorax johnsoni*, *Rhinomuraena quaestia* and *Strophidon sathete* were identified and reported for the first time in the Persian Gulf and Oman Sea's waters.

KEYWORDS: Muraenidae, systematic review, Persian Gulf, Oman Sea.

I. INTRODUCTION

Anguilliformes order included 4 subclass, 18 families, 156 genera and more than 500 species (Vander laan et al., 2013). There appeared 9 families in Iranian waters; consisting of Anguillidae, Mastacembliidae (Echelidae), Muraenesocidae, Muraenidae, Ophichthidae, Ophidiidae (from: Ophiidiformes), Synbranchidae. Seven families are live in marine environments (Owfi, 2005a). It seems that previews author's do not discussed about two families as name Anguillidae and Echelidae, which their main habitats are in Iranian fresh water (Owfi and Rabbaniha, 2007). Eels and moray families (Anguilliformes order) are common group of fishes in the Persian Gulf and Oman Sea. They have ornamental respect and food value in some species. They are eel shape and long body, have small pectoral and anal fins. In some species anal and pectoral fins are not presented. Almost they have long dorsal fin through the caudal fin. Fins have soft rays without spines. Have cycloid and under skin scales. Pelvic fins are absence, holobranchia or have bronchia pit on beneath or side of the head (Froese, et al., 2013). Characters research in Iranian waters of the Persian Gulf and Oman Sea divided to four stages included: (Owfi, 2005a).

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1st stage: Belgvad and Loppenthin, 1937; (Danish investigation) Introduced 216 species one genus and one species of it belong to Muraenidae

2nd stage: Kuronuma and Abe, 1968-1972; (KISR investigation) I introduced 465 species consisting of 244 collected commercial species and 222 reported species, two families in two genus and species belong to the sea's eels. FAO, 1977-1978; (FAO investigation), introduced 82 commercial species.

3rd stage: Fischer, 1984 (FAO investigation); introduced 380 species from fishing area 51. Bianchi, 1985 introduced three families of eels in six genus and species. Coad, 1992; Abdessalam, 1995 were introduced Four genus and five species in two families of eels; Randall and Carpenter, 1997 which introduced 577 commercial and noncommercial fish species.

4th stage: After 2000 investigation: Dehghani & Asadi 1996; introduced 260 species consisting of 77 families, Javid mohammad pour et al., 2001; Hoseinzadeh and Kamali, 2003; introduced 114 Ornamental marine species consisting of 44 families. Owfi, 2005; introduced 902 species, and Yasemi et al., 2008. So, recent study has done by the goal of to achieve the specific and new information about muraenidae taxonomy, systematic and morphology of the Eels and morays in Iran. According to related studies, there has not yet been a documented examination on systematic identification and taxonomic of eels. Actually, most of the ichthyologic studies on eels have been local studies. This article is specifically about Muraenidae family. However these fish are economical, Ornamental, and lemon sole, they are religiously taboo in Iran. So there were some limitations in collecting samples, examining, identifying and classifying the species.

II. MATERIAL AND METHODS

All museum samples of the Muraenidae were collected in Iranian terrestrial waters of the Persian Gulf and the Oman Sea since 1976 - 2006. The present study reviewed to the 13 samples from Muraenidae family in 2006 – 2008. 5 genera and 9 species by different types of keeping like taxidermy or fixed in formalin dedicated in Iranian museums. This fish species following list: (Table1).

Marine Biology Museum - Shrimp Research Center - Bushehr - Ref. Code: A

Biology Laboratory - Offshore Fisheries Research Center - Chabahar – Ref. code: B

Zoology Museum - Tehran University - Tehran – Ref. code: C
Ichthyology Museum - Fisheries Education Center – Rasht – Ref. code: D

Iranian Natural History and Wildlife Museum - Tehran – Ref. code: E

Assessment of Biometrical Parameters and appearance characters were classified in two groups.

1- Meristic parameters included of: Total length, Fork length, Standard length, Fins length ,Fin base, Caudal peduncle length, Head length , Snout length , Eye diameter , Body depth and in some parts use the relation parts for identify keys.

2- Morphometrical parameters, such as: Number of vertebrate, soft rays and spines, Scales, Teeth, Head spines, upper and lower spines of gill arch (Biswas, 1993). Used microscope and binocular, Biometrical board, caulis by 0.01 attention, magnifying glass, this information recorded in identification sheet. Samples categorized on different family taxon (Fischer and Bianchi, 1984; Smith& Heemstera, 1986).

Identifying in genus and species by fins formula standard identification table (Smith & Heemstera, 1986).Comparing the sample of diagnostic characters by valid reference qualities and Ichthyologic reliable sites such as: Fish Base, Reef Base, and Fish Catalogue of Life for finally accordance and species collation (Smith & Heemstera, 1986; Abdessalam, 1995, Carpenter, 1997).

This argues mentioned that, all of the specimens were collected and studied from museums, therefore were limited some morphometrics and merestics parameters clarifying.

III. RESULTS

Muraenidae Included 15 genera and 200 species, and 5 genera and 9 species identified from Muraninae subfamily. Generally collected in Raamin, Gowatr, Meidani, Kolahi Creek (Oman Sea - Sistan & Baluchistan province); and also Khark, Lavan, Sirri and Kish islands (Persian Gulf - Hormozgan province) areas (Table1).

1) *Echidna nebulosa* (Ahl, 1789):

English name: Starry Moray

Persian name: Mar Mahi –e-Setareie.

Morphology: Maximum size of total length is 100 cm. 119-126 numbers of vertebrae, No spin and soft ray of the dorsal and anal fins, yellow eyes, white body with two rows of large dendritic black blotches, black spots between blotches become irregularly linear with age (Fig. 1). Find and identified out one of them in Ramin and Kolahi Creek of the Oman Sea Iranian waters that were kept in Biology Laboratory - Offshore Fisheries Research Center - Chabahar (Ref.code:B) by museum code F-173 and with out scientific code(Table1).



Figure 1: *Echidna nebulosa* (Ahl, 1789)

Ref code: B, By Abbasi, 2007

2) *Gymnomuraena zebra* (Shaw,1797):

English name: Zebra Moray

Persian name: Mar Mahi –e-Gourekhari.

Morphology: Maximum size of total length is 150 cm. 132-137 numbers of vertebrae, No spin and soft ray of the dorsal and anal fins, narrow and black strips on the body, gravelly teeth, and rounded snout. Find and identified out one of them in Marine Biology Museum – Shrimp Research Center - Bushehr (Ref. Code: A),with out scientific and museum codes.

3) *Gymnothorax johnsoni* (Smith, 1962)

English name: White Spotted Moray

Persian name: Mar Mahi -e- Khal Sefid.

Morphology: Maximum size of total length is 130 cm. 135-137 numbers of vertebrae, body color is pale brown with irregular, and light spots anteriorly, larger and more rounded on tail and in young corner of mouth and gill opening dusky. Find and identified out 3 specimens in this study. Two of them collected from Ramin and Kolahi Creek of the Oman Sea Iranian waters that were kept in Tehran University. Zoology Museum (Ref. Code: C) by museum code F-176 and with out scientific code (Table1). The Third one collected from Gowatr Bay of Oman Sea and was kept in Ichthyology Museum Rasht (Ref. code:D) by scientific code 102 and museum code Muraena G.j.2. (Fig. 2, Table1).



Figure 2: *Gymnothorax johnsoni*

Ref. code: D, and C, Owfi, 2007

4) *Gymnattorax Kidako* (Temminck & Schlege, 1846)

English name: Kidako Moray

Persian name: Mar Mahi -e- Ghahveii

Morphology: Maximum size of total length is 120 cm. highest standard length is 91.5 cm. Finding and collects in Khark, Kish, Lavan and Sirri Islands waters of Iran easily, because of living in the coral and rocky caves. Observed one sample of that in this study and kept in Chahbahar Offshore Fisheries Research Center (Ref. code: B) without scientific and Museum codes (Table1).

5) *Gymnothorax Phasmatodes*

English name: Phantom moray

Persian name: Mar Mahi

Morphology: Maximum total length was 46 cm. and body color was pale yellow, lighter ventrally but we can't identification the sample carefully, because it's not preserved suitable in sample museum box (Table1).collected from

Iranian waters of the Oman Sea. It's seems to this species character, recorded the suspecting sample in Tehran Uni. Zoology Museum (Ref. code: C) with scientific code G. sp and none museum code.

6) *Gymnothorax. Sp:*

Morphology : Maximum total length was 50 cm, Milky body, no spin and soft rays on the dorsal and anal fins, Conical teeth in a row, tubular nasal cavity It's seems to this species character, recorded the suspecting sample in Tehran University. Zoology Museum (Ref. code: C) with scientific code G. sp and none museum code.

7) *Gymnothorax undulates*

English name: undulated moray
Persian name: Mar Mahi e Manghout

Morphology: Maximum total length is 120 cm. number of vertebrate is 126-138. Dorsal and Anal spines are 0-0; body color is brown, lines on the body have dark green spots, yellow snout, fierce species.3 samples of them found and identified in Oman Sea waters of Iranian sea zone from Meidani , Ramin and Bushehr waters of the Persian Gulf. This samples kept in Ichthyology Museum Rasht (Ref. Code: D), by 102 museum code and Muraenin G.U.2 scientific code, Iranian Natural History and Wildlife Museum, Tehran (Ref. code: E) and Tehran Uni. Zoology Museum (Ref. code: C) (Fig. 3, Table 1).

8) *Rhinomuraena quaestia*(Garman,1888):

English name: Ribbon Moray
Persian name: Mar Mahi -e- Abi
Morphology: Maximum total length was 130 cm; dorsal and anal spines are zero. Has three fleshy tentacles on the tip of its lower jaw, a single fleshy pointed projection at the tip of its, snout and tubular anterior nostrils ending in gaudy, fanlike expansions. Juveniles all black, males have yellow dorsal fins and fameless change to a nearly all yellow color, but usually with blue in posterior. Collected this sample in Oman Sea waters of Iranian sea zone from Meidani and kept in Ichthyology Museum by 102 scientific code and museum code Muraenin R.q.3 (Fig. 4, Table1).

9) *Strophidon sathete* (Hamilton, 1822)

English name: Slender Giant Moray
Persian name: Mar Mahi -e- Bozorg
Morphology: Maximum total length is 400 cm. number of vertebrate is 183-196. Dorsal and Anal spines are 0-0; body color is brownish grey in above and lighter below. Body moderately elongate, cylindrical in front, compressed along tail. Eyes small, teeth small, biserial, inner series enlarged head not obviously distinct from trunk. Although the profile is moderately steep, very large mouth, extended to beyond eye, biserial sharp teeth on jaws. Dorsal fin inserted on head before gill-opening; scales absents. Collected from Meidani zone in Iranian waters o the Oman Sea and kept in Ichthyology Museum Rasht (Ref. Code: D), by 102 scientific code and Muraenin S.s.4 museum code (Table1).



Figure3: *Gymnothorax undulatus* (Lacepede, 1803), Ref. code: C, D and E Abbasi and Owfi, 2007



Figure 4: *Rhinomuraena quaestia*(Garman,1888), Ref. code: D Owfi, 2007

Table 1: Muraenidae species check list of Iranian Museums from the Persian Gulf and Oman Sea, Base on ecological group.

Scientific name	Number of sample	Research centers and Museums					Museum code	Scientific code
		A	B	C	D	E		
<i>Echidna nebulosa</i>	1		*				-	F-173
<i>Gymnomuraena zebra</i>	1	*					-	-
<i>Gymnothorax johnsoni</i>	3			*	*		Muraena G.j2	F-176, 102
<i>Gymnattorax Kidako</i>	1		*					
<i>Gymnothorax Phasmatodes</i>	1			*				
<i>Gymnothorax. Sp</i>	1			*				
<i>Gymnothorax undulates</i>	3			*	*	*	Muraena G.u2	F-175, 102
<i>Rhinomuraena quaestia</i>	1				*		Muraenin R.q.3	102
<i>Strophidon sathete</i>	1				*		Muraenin S.s.4	102

IV. DISCUSSION AND CONCLUSION

The eels and morays are not edible and un-common groups in Iranian market. It has an unusual in fisheries exploitation system, thus would be limited in taxonomical research carefully. In the studied area there is less attention to noncommercial fishes. Hence data collections are very limited in taxonomical research of this species. From conclusively the lack of the public systematic studies in the region had led to misidentification of the species. So any review to identification and classification of the species are necessary although is not easy. In this regard it should be mentioned that 6 species of eels and moray (Muraenidae) have not been reported so far. So, this is the first record and report from mentioned species in Iranian waters (Table 1&2).

Necessary and the first factor of biological studies in each research can be true knowledge on the morphological characters of dwellers, Asses sex related and breeding fecundity across the optimum biological specialist too (Owfi, 2005a). In the research pay attention to final classification changing around all taxons of order including family, genera and species. All systematic information presented in table.1. This information basis to compose correct scientific name and identification species by collected or /and comparing this data by Owfi, 2005(a and b) reported (Table3).

Based on the available data, it was obvious that 7 samples of Muraenidae belonging to 3 genera and 3 spices were observed for the first time in Iranian waters (table2).There were some similarities and differences between these identified samples and the ones identified on the UNCC project (Owfi,2005b)(Table3).

a. Based on the reports, of the UNCC project 5 samples of this family identified (Owfi, 2005a&b).

b. Just the family taxa, genera and species of the samples were identified.

c. Four samples of this project and (Owfi, 2005b) were the same, one unknown sample, 7 new samples and one renamed sample.

By comparing this project and UNCC (Owfi 2005b) it was obvious that there were four common samples in these two projects: *Gymnothorax undulates*, a native species of Iran (Belgvad & Loppenthin, 1937). This species was also found in the waters of the Persian Gulf and Oman Sea's neighboring countries such as: Kuwait(Randall, 1995), Oman(Carpenter et al, 1997; Al.Abdessalam, 1995), Bahrain (Al.Bahrana, 1986), the east of Saudi Arabia, United Arab Emirates and Qatar (carpenter et al, 1997). Some reports showed that this species existed also in far waters which were similar to Iranian waters of Persian Gulf and Oman Sea from the view point of ecosystem, such as Somali(Sommer, 1996), Sri Lanka(Deburin, 1994).

Table 2- First record and reported of Muraenidae species in the Persian Gulf and Oman Sea Iranian waters.

Scientific name	Number of sample	Research centers and Museums					Museum code	Scientific code
		A	B	C	D	E		
<i>Gymnomuraena zebra</i>	1	*					-	-
<i>Gymnothorax johnsoni</i>	3			*	*		Muraena G.j2	F-176, 102
<i>Gymnattorax Kidako</i>	1		*					
<i>Gymnothorax Phasmatodes</i>	1			*				
<i>Gymnothorax. Sp</i>	1			*				
<i>Gymnothorax undulates</i>	3			*	*	*	Muraena G.u2	F-175, 102
<i>Rhinomuraena quaestia</i>	1				*		Muraenin R.q.3	102
<i>Strophidon sathete</i>	1				*		Muraenin S.s.4	102

Echidna nebulosa and *Gymnomuraena zebra* were species that were observed by marine patrol in Iranian waters of Persian Gulf and Oman Sea during 2001 – 2002 for the first time. Existence of these spices in the waters of south of Iran confirmed by Owfi's report (2005) after reviewing some reports about their existence in neighboring countries such as Oman's waters (Al-Abdessalam, 1995), Bahrain (Al.Bahrana, 1986) and Kuwait (Carpenter et al, 1997).

Table 3: Determined Muraenidae species of the Persian Gulf & Oman Sea 2005 (Owfi, 2005b).

Scientific name	References						
	A	B	C	D	E	F	G
<i>Echidna nebulosa</i> (Ahl,1789)			*	*			*
<i>Gymnomuraena zebra</i> (Shaw,1797)				*			
<i>Gymnothorax phasmatodes</i> (Smith,1962)				*			
<i>Gymnothorax undulates</i> (Lacepede,1803)				*			
<i>Thyrsoidea macrura</i> (Bleeker,1854)				*			

A: Iranian Fisheries Research Organization – IFRO (1986-88)

B: Marine Science and Fisheries Center of Oman – MSFCO (1995)

C: Kuwait Institute for Scientific Research – KISR (1986)

D: Iranian Fisheries Research Organization – IFRO (2001-02)

E: FAO, 1986, F: FAO, 1997, G: Owfi, 2005

Gymnothorax Phasmatodes species was also identified by marine patrol in Iranian waters of Persian Gulf and Oman Sea for the first time, during 2001- 2002. Reviewing the given reports about its existence in Kuwait's waters (Randall, 1995), Oman's coastal waters (Carpenter et al, 1997) and Sri Lanka's waters (Deburin, 1994) systematically, it was proved that this species followed the reports; UNCC report also verified its existence in Iran's waters. The others seven species examined in this study were mostly emigrants to Iranian waters of Persian Gulf and Oman Sea. Existence of *Gymnthorx johnsoni* species was verified according to given data and the report that confirmed its existence in Kuwait's waters (Carpenter et al, 1997), Oman's coastal waters (Al-Abdessalam, 1995); (Randall, 1995), and Aqaba Gulf's waters (Khalaf,A.Marroof & Disi, 1997).

Existence of *Gymnothorax kidako* species was proved by the studies carried out by Hoseynzadeh and Kamaki, 2003 . They took the sample to the Offshore Fisheries Research Center - Chabahar to identify it. Given data followed the reports of its existence in the waters of Australia (Kuitert, 2002) and Sri Lanka (Deburin, 1994). *Gymnothorax sp* has been already seen by Carpenter et al, 1997 in Oman Sea, Kuwait's coral areas waters (Sommer, 1996), waters of Somalia (Smith & Himstera, 1986) and Indian Ocean. *Rhinomuraena quaestia* has been observed in Pakistan's waters (Bianchi, 1995), Aqaba's waters (Khalaf, A.Marroof & Disi, 1997) and Australia's waters (Kuitert, 2002).

After collecting systematic data about given species, comparing the data by available reports, gathering more samples of given species and finally confirming their existence in Indian Ocean by referring to reference websites of ichthyology -such as Fish base, 2013 and Fish catalogue of life, 2008- this study has verified that these species have existed in Iranian waters of Oman Sea and Persian Gulf.

Strophidon sathetes species which called *Thysoidea macrura* (Bleeker, 1854) in UNCC project (Owfi,2005b), has been observed in Pakistan's waters (Bianchi, 1995), Oman's waters (Randall, 1995) and in Iranian waters of Oman Sea and Persian Gulf by Iran's marine patrol (2001-2002).

Table 4: Changed name of Muraenidae Species base on ecological groups.

Accepted scientific name	Reference	Changed scientific name
<i>Strophidon sathete</i> (Hamilton,1822)	(Fish base, 2013; Vander laan <i>et. al.</i> , 2013)	<i>Thyrsoidea macrura</i> (Bleeker,1854)
<i>Gymnothorax undulates</i>	(Smith& Smith,1963)	<i>Licodontis undulatus</i>
<i>Gymnothorax johnsoni</i>	(Smith& Smith,1963)	<i>Licodontis johnsoni</i>

However this sample was gathered up of Iran`s waters and was taken to ichthyology Museum Rasht. After examining the data, comparing to available reports and the confirmation of reference websites of ichthyology -such as Fish base, 2013 and Fish catalogue of life, 2008- the existence of this spices in Iranian waters of Oman Sea and Persian Gulf has been proved (Table 4) .

Table 5: Muraindae species diversity of the Persian Gulf and Oman Sea, base on ecological groups

Scientific name	English name	Persian Gulf	Oman Sea	Ecologic group
<i>Echidna nebulosa</i> (Ah1,1789)	Starry moray	*	*	D
<i>Gymnomuraena zebra</i> (Shaw,1797)	Zebra moray	*	*	D
<i>Gymnothorax Johnsoni</i> (Smith,1962)	White spotted moray	*	*	D
<i>Gymnothorax kidako</i> (Temminck & Schlegel,1846)	Kidako moray	*	*	R&D
<i>Gymnothorax phasmatodes</i> (Smit,1962)	Phantom moray	*	D
<i>Gymnothorax sp</i>		*	?	
<i>Gymnothorax undulates</i> (Lacepede,1803)	Undulated moray	*	*	D
<i>Rhinomuraena qyaestia</i> (Garman,1888)	Ribbon moray	*	*	
<i>Strophidon sathete</i> (Hamilton,1822)	Giant slender moray	*	*	R&D

D: Deep water, R: Rocky water, R&D: Rocky and Deep water.

It should be noted that, obtained samples regardless previous ones (the samples that have been already observed by marine patrol during 2001-2002) was about 29.62% of all the eels identified in Oman Sea and Persian Gulf`s waters. Considering all the samples identified so far by marine patrols and previous researches it was about 33.3% of all the eels of Iran`s waters. In the light of biological diversity, there were 3 genera and 5 species (8 samples) lived in deep waters; 2 genera and 2 species (2 samples) lived in rocky zones and deep waters of Iran. The ecological group - biological diversity- of 3 samples consisted of 3 specie and 3genera has not been specified so far (Table 5).

According to the conclusion significance and main suggestions of research included of:

A) Less taxonomical information about this class biodiversity in many parts of the world.

B) Need to power of taxonomical background; consist of reference subject, information banks, and taxonomical experts through the biodiversity of convection in whole area especially on under developed countries.

C) Taxonomical defects of Anguilliformes in national & territorial levels.

D) Help to kept of humanly resources, would be hatched &collected samples systems and under structure, then changed them to curate forms. In addition to several problems in this way; the project is the first complete and collected information about the order and showed the vague side of eels and morays classification.

E) Recognized the classified position, emphasis to geographical division categories reviews and defects of specimen in the area. Classified coastal land & marine environmental diversities, describe Persian Gulf and Oman Sea`s Muraenidae by Linnae & Mayer classification and animal geography theories.

F) Use the results of ichthyology research in fisheries management and planning to calculate& assess of sustainable yield recruitments on special species or group species, health &disease of fish aspect special hosts such as parasites or other parts of disease in marine environments because eels and morays live in salt waters and non culture in Iranian waters, thus give in information results to Iranian fisheries science & Research organization and Iranian fisheries organization.

G) Identification and complete information about Marine morays fauna by the goal of stock flexibility/species combination (species diversity index). Planning about endemic and endangered species biodiversity, survey and doing sustainable study in this chart and know the effects of ecological or environmental changing by human or natural too.

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