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journal homepage: <http://ees.elsevier.com/apjtm>Original research <https://doi.org/10.1016/j.apjtm.2017.10.024>Faunal data and envenomation emergency first aid of cone snails (*Conus* spp.) in Qeshm Island, the Persian GulfMehdi Khoobdel<sup>1</sup>, Hadi Dehghani<sup>2</sup>, Ali Mehrabi Tavana<sup>3</sup>, Mohammad Ghasemi<sup>1</sup>, Seyyed Mohammad Dakhteh<sup>4</sup>, Majid Askari Hesni<sup>5</sup>, Mohsen Rezaie-Atagholipour<sup>1,✉</sup><sup>1</sup>Health Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran<sup>2</sup>Department of Marine Biology, Faculty of Science, University of Hormozgan, Bandar Abbas, Iran<sup>3</sup>Health Management Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran<sup>4</sup>Environmental Management Office, Qeshm Free Area Organization, Qeshm Island, Iran<sup>5</sup>Department of Biology, Faculty of Science, Shahid Bahonar University of Kerman, Kerman, Iran

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## ABSTRACT

**Objective:** To investigate the fauna of a highly venomous marine species group, the cone snails (Family Conidae), in the shores of Qeshm Island, of evaluating the possibility of envenomation in the area and summarize recommendations for emergency first aid.**Methods:** Shores surrounding Qeshm Island were surveyed to collect cone snails during cold (February and March) and warm (May and June) seasons of 2017. Collected snails were identified to the species level. Abundance and species richness were estimated in shores of different structures, including muddy and sandy-rocky shores. Also, the most updated medical literature was reviewed to summarize related emergency first aid.**Results:** Three cone snail species were recorded from southern sandy-rocky shores of the Island, in decreasing order of abundance, included crowned cone (*Conus coronatus*) (65%), feathered cone (*Conus pennaceus*) (28%), and frigid cone (*Conus frigidus*) (7%). Abundance of these species were significantly higher in cold season compared to the warm season ( $P < 0.05$ ). No cone snails were recorded along the northern muddy shores of the Island.**Conclusions:** Envenomation can cause various symptoms ranging from minor local pain to systemic paralysis and death due to respiratory failure. We recommend an awareness programme for the seashore visiting public.

## 1. Introduction

Human-marine wildlife interaction is an occasional or daily occurrence for many people all around the world, including fishermen, divers, swimmers, boaters, surfers, etc. However, this interaction is not always safe as many species of marine wildlife are potentially capable of causing serious and fatal human injuries [1,2]. According to the type of the injuries, these hazardous marine species fall into four groups, including traumatogenic

animals (causing traumatic injuries using spines, stingers and teeth), strongly electric fishes (causing shock injuries), poisonous animals (causing deleterious effects when they are ingested or touched by the victim), and venomous animals. The fourth and last group includes animals which can cause marine envenomation, as they can inject toxins into the body of a human victim using an apparatus such as spines, stingers or teeth. These toxins have diverse deleterious effects on the victim including proteolysis, myotoxicity, hemotoxicity, cytotoxicity and neurotoxicity [1,3]. Marine envenomations annually cause a lot of emergency situations for humans worldwide [1], especially throughout the tropical coastal waters of the Indo-West Pacific [4]. Immediate first aid before full medical treatment is critical to mitigate the dangerous consequences of marine envenomations [1,2,5,6].

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Cone snails, also known as cone shells (family Conidae), are marine predatory snails of the genus *Conus* spp., the largest genus of marine invertebrates. These marine gastropods occur throughout all tropical and subtropical coastal waters around the world, but are most diverse in the Indo-West Pacific region [7]. Cone snails have a specialized venom apparatus containing several venomous biological harpoons. In contact with a prey or predator, the snail is able to extend its proboscis and spear its victim with one of those harpoons [7,8]. With an estimated number of 140 000 to 700 000 cone snails' venom peptides, also known as conopeptides [8], it is not surprising that 700 species of the genus *Conus* containing the largest and most clinically important pharmacopoeia of any animal genus on our planet [9]. Not all, but some of these peptides have toxic effects on humans causing various consequences ranging from minor local pain to systemic paralysis and death due to respiratory failure [8].

Therefore, this study was carried out to investigate local medically important venomous fauna present in coastal waters surrounding Qeshm Island, the largest Island in the Persian Gulf. Further, the study presents putative symptoms and emergency first aid for envenomation of these venomous species, through a review of the most updated literature.

## 2. Material and methods

Qeshm Island, with an area of about 1390 km<sup>2</sup>, hosts about 149 000 residents. Further, thousands of Iranian and foreign tourists visit the Island annually as it is famous for several natural national monuments and protected areas. Furthermore, Qeshm Island has been designated a Free Trade Zone by the Iranian government, and is therefore of interest for thousands of Iranians, who immigrate to the Island seeking labor opportunities. The central part of this large island is mostly covered by deserted, non-residential areas. On the other hand, the coastline surrounding Qeshm Island, with a length of about 290 km, hosts the highest proportion of the residents, immigrant and tourist populations [10]. All these people when visiting the shores and coastal waters could be potentially exposed to natural threats existing in the Persian Gulf, in which one of those is marine envenomation [2]. The shores of Qeshm Island can be divided into two different types. The northern shore (of the island) is a sheltered area located at a narrow channel between Qeshm Island and the Iranian mainland, where it is covered by mud flats and mangrove forests. On the other hand, the southern shore of the island is an open area exposed to waves, and is covered by sandy and rocky habitats.

In this study, both the northern and southern shores of the Island were monitored through planned and off-effort field surveys in both the cold (February and March) and warm (May and June) seasons of 2017. Cone snails were collected by walking through the intertidal zone during highest low tides and checking under rocks and rubbles. The snails were picked up carefully and fixed in 75% ethanol for later examination. Due to the fact that most species of this genus are threatened by population decline [9], only one specimen from each putative species was collected for next laboratory examination, and all other specimens released at their own habitat after examination. Collected specimens were identified to the species level using appropriate identification keys [11].

Simpson's diversity index-1 (SDI-1) was used to estimate species dominance in the cone snail community of Qeshm Island. The formula of the index is as follows [12]:

$$SDI-1 = \left[ \sum_{i=1}^N \left( \frac{n_i}{N} \right)^2 \right] - 1$$

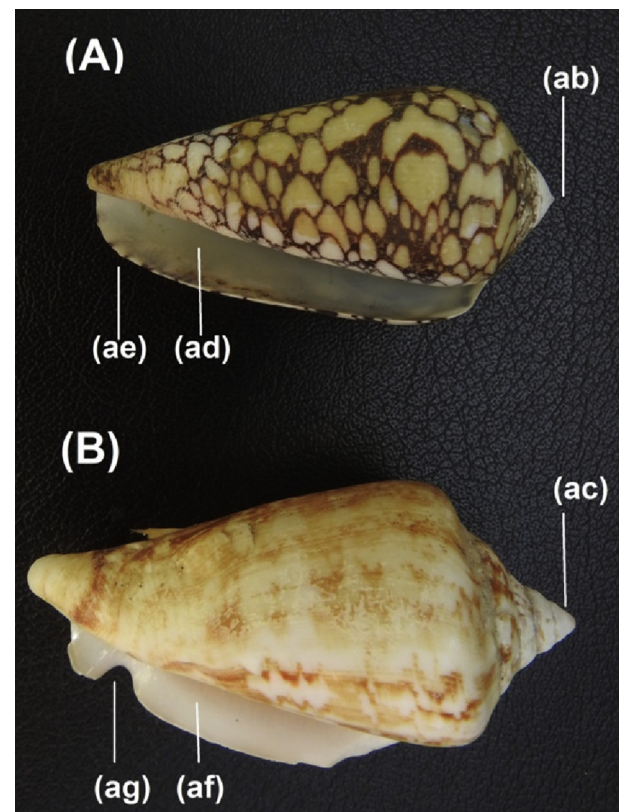
where  $n_i$  is the number of species  $i$ , and  $N$  is total number of all species in the sample collection. The SDI-1 value ranges between 0 and 1, of which 0 shows lowest and 1 shows highest species richness [12]. Further, differences in abundance of cone snails between cold and warm seasons were tested using Mann–Whitney  $U$  test;  $P < 0.05$  was assumed as significant.

After collecting faunal data from the study area, the most updated and cited medical literature was reviewed to gather some information about the risk of envenomation by the identified species, envenomation symptoms and first aid options for emergencies.

## 3. Results

### 3.1. Distinguishing cone snails from similar species in the area

Several harmless species of marine snails occur along the intertidal shores of Qeshm Island which morphologically resemble venomous cone snails. The shells of *Conus* species could be distinguished from these similar harmless shells (e.g., *Conomurex* spp) using the two following diagnostic characters:



**Figure 1.** Comparison between (A) a venomous cone shell (*Conus pennanceus*) and (B) a harmless conch shell (*Conomurex* sp.).

Both specimens were collected from intertidal shores of southern Qeshm Island. The shells distinguished from each other using the two diagnostic characters: 1) *Conus* spp. have a cone-shaped shell with a low broad conical spire on the apex (ab), whereas *Conomurex* spp. have a sharp and separated short spire on the apex (ac); 2) *Conus* spp. have a long and narrow aperture (ad) and a straight lip (ae), whereas *Conomurex* spp. have a shorter aperture (af) with an untidy lip (ag) that usually has a notch on its anterior end (ae).

**Table 1**Faunal data of cone snails (*Conus* spp.) distributed through the shores of Qeshm Island, Persian Gulf [*n* (%)].

Species	Cold season		Warm season		Both seasons	<i>P</i> -value
	Rocky shores	Muddy shores	Rocky shores	Muddy shores		
Crowned cone ( <i>C. coronatus</i> )	27 (59)	0 (0)	3 (6)	0 (0)	30 (65)	0.00001
Frigid cone ( <i>C. frigidus</i> )	3 (6)	0 (0)	0 (0)	0 (0)	3 (7)	–
Feathered cone ( <i>C. pennaceus</i> )	12 (26)	0 (0)	1 (2)	0 (0)	13 (28)	0.00014
Total species	42 (91)	0 (0)	4 (9)	0 (0)	46 (100)	0.00001

The shores were surveyed during cold (February and March) and warm (May and June) seasons of 2017. All percentage data indicate percentage of all collected specimens.

(i) Cone snails have a cone-shaped shell with a low broad conical spire on the apex, whereas other similar species have a sharp and separated short spire on the apex (Figure 1). (ii) In cone snails, the opening of the shell (aperture) is long and narrow and its free margin (the lip) is straight. But aperture in other similar species (e.g. conch snails in the genus *Conomurex* spp.) is shorter with an untidy lip that usually has a notch on its anterior end (Figure 1).

### 3.2. Faunal data of cone snail species in the area

Table 1 shows faunal data of cone snail species recorded in this study. In total, three species of cone snails were recorded from intertidal shores around Qeshm Island, including crowned cone [*Conus coronatus* Gmelin, 1791; (*C. coronatus*)], frigid cone [*Conus frigidus* Reeve, 1848; (*C. frigidus*)] and feathered cone [*Conus pennaceus* Born, 1778; (*C. pennaceus*)]. All these three species were only occurred through rocky-sandy shores of southern Qeshm Island. Abundance of all these species was significantly higher in cold season compared to the warm season ( $P < 0.05$ ; Table 1). The value of SDI-1 was 0.49, which showed that not all three species are dominant in the area.

#### 3.2.1. Crowned cone snail (*C. coronatus*)

This species has a small to medium sized shell (maximum length 4 cm, commonly to 3 cm), which is light to solid. The shell also seems massy with a bellied apex and convex margin (Figure 2). The color pattern of the shells examined in this study was gray brownish to olive, sometimes with some dark spiral bands.

In total, 30 specimens of this species were found during this study, of which 27 were collected in cold season and three others were collected in warm season. All specimens of this species were collected from intertidal sandy-rocky shores on the southern Qeshm Island. It was the most abundant (65% of all collected specimens) and smallest (mean length about 3 cm) cone snail species in comparison with two other species.

#### 3.2.2. Feathered cone (*C. pennaceus*)

This species has a solid to heavy shell, which is slightly convex with a low to moderately high spire (Figure 2). Shells collected in this study had a pinkish cream background with many small to large whitish tent-like markings.

In total, 13 specimens of this species were found in this study, 12 in cold season and only one in the warm season. Therefore, it was found to be the second most abundant cone snail species (28% of all specimens) after *C. coronatus*, and similarly to the two other species, it only occurred in sandy-rocky shores of southern Qeshm Island.

#### 3.2.3. Frigid cone snail (*C. frigidus*)

This species has a solid medium sized shell (3–6 cm length), which could be recognized by a low spire and sharply increasing of width toward apex (Figure 2). The color of the shells examined in this study was brownish orange with one horizontal paler band on the top and sometimes one more on the mid of the shell.

In this study, only three specimens of the species were found in intertidal sandy-rocky shores of southern Qeshm Island during the cold season. Frigid cone snail was found to be the rarest species (7% of all specimens) among the three cone snail species observed in the area.



**Figure 2.** The shell of (A) frigid cone snail (*C. frigidus*), (B) crowned cone snail (*C. coronatus*), and (C) feathered cone (*C. pennaceus*).

## 4. Discussion

### 4.1. Cone snail diversity and risk of envenomation in Qeshm Island

There are three issues that should be discussed in order to draw a clear insight into the risks of human envenomation by cone snails along the shores of Qeshm Island. These issues concern diversity, species richness and feeding habits of cone snails living along the shores of the island.

With regard to cone snail diversity and species richness in Qeshm Island, of about 700 cone snail species recorded worldwide, only three species were found by this study in the sandy-rocky shore of the study area. However, other studies also recorded *Conus flavidus* (*C. flavidus*) and *Conus textile* (*C. textile*) in the same area [13–16]. Although, based on examining the figures presented by some of these studies, it seems likely that the authors probably confused *C. frigidus* with *C. flavidus* and *C. pennaceus* with *C. textile*. It is not surprising as the species in each of these two pairs show high morphological similarity and could be easily confused with each other [12]. However, we could not surely reject the possibility of the presence of *C. flavidus* and *C. textile* in the area, because we were not able to directly examine the discussed specimens. Even by adding these two species to the cone snail species list of Qeshm Island, the total number of the species will be five, which shows low diversity for this genus in the area. Further, our results show low species richness (SDI-1 = 0.49) for the cone snails through the area. Nonetheless, low diversity and species richness do not necessarily decrease the risk of human injuries caused by cone snails, also as one of the species, the crowned cone (*C. coronatus*), appeared to be fairly common (*C. coronatus*). Because although lower abundance means lower possibility of human encounters with these hazardous shells, it also means that fewer people are aware of the risk in any possible encounter.

The second important item that is related with the risk of cone snail envenomation in Qeshm Island is the preferred habitats of these animals. Here in this study we found that cone snails only occurred in sandy-rocky and reef habitats of the southern shores of Qeshm Island. Not herein nor in other studies [13–16], were specimens of cone snails recorded from the muddy habitats of the northern shore. This is natural because cone snails as a family mostly prefer to live in inshore shallow coral reef habitats [7]. Therefore, the main risk of human injuries by cone snail envenomation is for persons who visit the southern shore of the Island.

Most species of cone snails are worm eater but others are also mollusc eater and fish eater [8]. These feeding strategies can determine the risk that these marine snails are able to endanger human health. The most dangerous conotoxins for humans are those evolved in fish eater cone snails, followed by mollusc eaters and finally worm eaters. For example, most worldwide records of human fatalities caused by cone snail envenomation have been attributed to geography cone (*Conus geographus*) [8].

### 4.2. Cone snail envenomation symptoms

In cone snail envenomation, the venom simultaneously delivers several toxic neuroactive peptides to the body of the victim [8]. Therefore, it is difficult to say which group of these

toxins is exactly responsible for a particular envenomation symptom. Moreover, our knowledge about cone snail envenomation is so limited, because only few detailed records exist worldwide on patients envenomed by these marine snails. Because of these two issues, it is difficult to attribute a specific symptom to a specific cone snail species [8]. But common symptoms of cone snail envenomation are described. Although, not all of the symptoms will be necessarily seen in a putative victim as the symptoms usually vary according to the cone snail species and depth of the envenomation. The cone snail general envenomation symptoms are summarized as follows [8,17]:

Local symptoms at the envenomation site: Restriction of blood supply to tissues (ischemia); Discoloration of skin (cyanosis); Sharp sensations of stinging, burning, pricking (paresthesia) or numbness or severe itching (pruritus). Local pain intensity varies among different persons. For some individuals it resembles wasp sting, whereas some others feel an excruciating pain; Fluid retention at the envenomation site that causes swelling (edema), which may also spread involving the entire limb.

Systemic symptoms: Spreading numbness and paresthesia, particularly about lips and mouth; Loss of voluntary muscle function (muscular paralysis), beginning by motor incoordination and followed by general muscular paralysis; Absence of limb reflexes; Inability to speak (aphonia), difficulty in swallowing (dysphagia) and in breathing (dyspnea); General pruritus; Blurred or double vision (diplopia); Nausea, but usually without gastrointestinal and genitourinary symptoms; Faintness, fatigue and malaise; Unconsciousness; Excessive flow of saliva (ptyalism); Falling of the upper eyelid (ptosis); Cardiac arrest resulting from cardiac impairment; Respiratory arrest (40 min–5 h after envenomation); Death, usually caused by respiratory failure.

### 4.3. Cone snail envenomation emergency first aid

The most deleterious effects of conotoxins appear at a couple of hours after cone snail envenomation. Therefore, an immediate first response to the emergency situation is necessary before reaching a medical facility [8]. The most important actions that must be done and those must be avoided in cone snail envenomations are summarized as follows:

Do: (i) Remove the victim from the water is the first priority (in the case that the victim was envenomed in the water during scuba diving, snorkeling, etc.). It is necessary to prevent the victim from drowning because of paralysis, coma or death. (ii) Transport the victim to the nearest health facility as quickly as possible. It is critical because fatal neurotoxic effects of the venom can appear rapidly, and therefore advanced medical care will be urgently needed. (iii) Airway protection with basic and advanced life support (BSL and ALS) must be remembered as oropharyngeal muscle paresis can lead to the risk of airway obstruction. (iv) Pressure-immobilization bandage technique as recommended for snake envenomation is strongly recommended to reduce venom distribution as much as possible. (v) Talk to the victim and be as reassuring as possible. It is important because the victim could be paralyzed but completely conscious. (vi) Mouth-to-mouth ventilation and cardiopulmonary resuscitation (CPR) may be necessary as failure of the respiratory musculature is usually the cause of death in cone snail envenomation. (vii) Remove all tight clothing and jewelry (such as rings, bracelets,

etc.) from the stung limb. While this step has been not recommended by other authors for cone snail envenomation, it is important because such items can cause harmful constriction in the case of swelling.

Do not: (i) Attempt to use incision, excision, suction, vinegar, alcohol, any home or medical solution, and heating or cooling at the envenomation site. Focusing on these unproved options not only are ineffective in treatment but also can be harmful for the victim. (ii) Elevate the envenomed limb, which causes faster venom distribution. (iii) Take alcohol or painkillers, even over the counter (OTC) ones, in the case of feeling an excruciating pain. Putative side effects of taking painkillers (e.g. interference with the metabolism or heart rate) could be dangerous for the patient, who already suffers from the systemic neurotoxic effects of the venom. Further, the victim must be coherent and aware of what is happening, which will be prevented by painkillers [18]. (v) Try to collect the cone snail specimen. Although, some authors mentioned it as one of first aid steps in cone snail envenomation [17], but we think it should be skipped. There is no antivenom for any specific cone snail species [8,17]. Therefore, retaining the shell, which requires caution for not putting another person in the risk of envenomation, is wasting time while the most important is prompt full attention to your patient.

#### 4.4. Prevention is better than cure

Although most marine envenomations happen by accident, like stepping on a stingray hidden in the bottom or touching tentacles of an invisible transparent jelly fish [1,2], cone snail envenomation never happens in an accidental contact between human and the animal [7,8]. Actually, in the presence of a potential predator, a cone snail always firstly avoids the threat and hides inside its shell without any other defensive reaction. But if the predator persists, then the snail inevitably will turn to an aggressive action and extends part of its body and its proboscis trying to sting the enemy. Human envenomation by cone snails will result from this defensive behavior, when the animal is being picked up by a shell collector, a researcher or a curious person [7,8]. Therefore, we strongly recommend that maritime medical experts, first aid instructors, and other specialists should teach members of the public who plan to visit tropical and subtropical seas, to identify cone snails and avoid them. Education is the most efficient and safest way to prevent deleterious consequences of contacts with these beautiful but hazardous seashells.

The results of this study suggest cone snail diversity and richness are low throughout the intertidal shores of Qeshm Island. However, this may not necessarily reduce the risk of envenomation by these creatures as low occurrence means fewer people are aware of the risk in any possible encounter. In any putative cone snail envenomation immediate first response is critical as the venom comprises many different kinds of neuroactive toxic peptides which can be lethal. We suggest that the development of an educational program for people who plan to visit the shores of Qeshm Island as to increase their awareness about these snails, and their understanding of the risks will be the safest, most effective and most economical way to reduce the risk of envenomation by cone snails in the area.

## Conflict of interest statement

All authors declare they have no conflict of interest.

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## References

- [1] Haddad V Jr. *Medical emergencies caused by aquatic animals: a zoological and clinical guide*. Switzerland: Springer International Publishing; 2016, p. 123.
- [2] Nobakht M. *Dangerous marine animals in the Persian Gulf and Caspian Sea: field guide for medical treatment*. Tehran: Asrar Danesh; 2014, p. 192 [Persian].
- [3] Schafermeyer R, Tenenbein M, Macias C, Sharieff G, Yamamoto L. *Strange and Schafermeyer's pediatric emergency medicine*. 4th ed. China: McGraw-Hill Education; 2014, p. 870.
- [4] Fenner P. Marine envenomation: an update – a presentation on the current status of marine envenomation first aid and medical treatments. *Emerg Med* 2000; **12**: 295-302.
- [5] Reese E, Depenbrock P. Water envenomations and stings. *Curr Sports Med Rep* 2014; **13**(2): 126-131.
- [6] Hornbeak KB, Auerbach PS. Marine envenomation. *Emerg Med Clin North Amer* 2017; **35**(2): 321-337.
- [7] Dutertre S, Lewis RJ. Cone snail biology, bioprospecting and conservation. In: Hämäläinen EM, editor. *Snails: biology, ecology and conservation*. UK: Nova Science Publishers; 2012, p. 185.
- [8] Kohn AJ. Human injuries and fatalities due to venomous marine snails of the family Conidae. *Int J Clin Pharmacol Ther* 2016; **54**(7): 524-538.
- [9] Chivian E, Roberts CM, Bernstein A. The threat to cone snails. *Science* 2003; **302**: 391.
- [10] Darehshouri BF. *The nature of Qeshm*. Tehran: Agah Publishing House; 2009, p. 180 [Persian].
- [11] Tucker JK, Tenorio MJ, Puillandre N. *Illustrated catalog of the living cone shells*. Wellington: Mdm Publishing; 2013, p. 517.
- [12] Ardakani MR. *Ecology*. 4th ed. Tehran: Tehran University Press; 2004, p. 340 [Persian].
- [13] Yekta FA, Izadi S, Asgari M. Distribution of rocky intertidal molluscs in Qeshm Island, the Persian Gulf. In: Chouikhi A, Khalaf G, Abisaab MA, editors. *INOC-CNRS, International Conference on "Land-sea interactions in the coastal zone"*. Lebanon: Jounieh; 2012, p. 6. November 6–8, 2012.
- [14] Asgari M, Yekta FA, Izadi S. Dominant intertidal crustacean and gastropod species in Qeshm Island, Iran, northern Persian Gulf. *Mar Biodiv Rec* 2012; **5**: 1-8.
- [15] Tabaraki N, Shahbazzadeh D, Moradi AM, Vosughi G, Mostafavi PG. Analgesic effect of Persian Gulf *Conus textile* venom. *Iran J Basic Med Sci* 2014; **17**: 793-797.
- [16] Yekta FA, Kiabi B, Ardalan AA, Shokri M. Temporal variation in rocky intertidal gastropods of Qeshm Island in the Persian Gulf. *J Persian Gulf* 2013; **4**(13): 9-18.
- [17] Halford ZA, Yu PYC, Likeman RK, Hawley-Molloy JS, Thomas C, Bingham J. Cone shell envenomation: epidemiology, pharmacology and medical care. *Diving Hyperb Med* 2015; **45**(3): 200-207.
- [18] Damian E. *Snakes of Arabia: a field guide to the snakes of Arabian Peninsula and its shores*. Dubai: Motivate Publishing Led; 2008, p. 208.