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POISONOUS AND VENOMOUS ORGANISMS OF THE NORTHERN ADRIATIC SEA

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ABSTRACT

*Several poisonous (toxic) and venomous species are known to live or sporadically occur in the northern part of the Adriatic Sea. Despite the fact that they generally do not represent a major health hazard, they certainly deserve our attention and knowledge about their biology, ecology and harmful substances they possess. The majority of toxic organisms that could be found in the northern Adriatic belong to a large group of single cell planktonic algae (Dinophyta). A vast number of toxic species are members of sponges (Porifera). Under certain circumstances some fish from the Scombridae family could also become toxic due to the improper storage and subsequent massive release of histamine in their bodies. Massive blooms of toxic dinoflagellates represent a major threat to human health due to the accumulation of their toxins in edible shellfish species like mussels (*Mytilus galloprovincialis*). Venomous animals (those who inject their toxins directly into the body of their victim) could be found in different groups of marine animals, most notably among coelenterates and fishes.*

Key words: venomous organisms, poisonous organisms, human health, Northern Adriatic

INTRODUCTION

Marine organisms are a vast source of toxic compounds with a broad spectrum of biological activities. Many are harmful to man, but only few of them can inflict serious enough envenomation/intoxication that could lead to the death of the inflicted person. In this regard, members of the dinoflagellates, cnidarians, molluscs and fishes deserve our special consideration. It is known that certain species of dinoflagellates and some diatoms cause serious, sometimes massive intoxication due to the ingestion of otherwise edible shellfish. In their tissues they accumulate harmful biotoxins that are produced during massive algal blooms and therefore become poisonous. Diarrheic (DSP), paralytic (PSP) and neurotoxic (NSP) intoxication are produced by different dinoflagellate species, while amnesic (ASP) symptoms are caused by diatom biotoxins. Ciguatera is another well-known disease with rather bizarre neurological symptoms. It occurs in tropics and subtropics and is caused by ingestion of poisonous predatory fish. These fish accumulate biotoxins through the food web. The source of biotoxins is the toxic benthic dinoflagellate *Gambierodiscus toxicus*. Sometimes it causes massive intoxication that is seldom fatal but could last for extended period of time (up to several months). Certain tissues of the notorious fugu fish (Tetraodontidae, puffer fish), which are considered a delicacy in Japan, are a prime source of tetrodotoxin, although this toxin could be also found in some other marine and even terrestrial organisms. The exact origin of the toxin is not known, although the growing evidence shows that certain bacteria are the source of the toxin. Tetrodotoxin blocks sodium channels in nerves and causes fatal respiratory paralysis. Venomous marine animals can inflict moderate to serious envenomation. Some of their toxins are powerful enough to kill an adult within a couple of minutes. Most venomous marine animals belong to cnidarians, molluscs, fishes and sea snakes. In this paper we will focus on the toxic and venomous organisms that inhabit the Northern Adriatic Sea.

TOXIC ALGAE AND THEIR BLOOMS

The Adriatic has been for a long time considered relatively safe in terms of toxic marine plankton blooms. However, the increased eutrophication in the Northern Adriatic basin during the last two decades resulted in

occurrence of several toxic dinoflagellate species and their blooms which affected mariculture production (Boni *et al.*, 1990; Malej *et al.*, 1997; Sedmak & Obal, 1998). The maricultures were periodically closed and shellfish sale was temporally banned by the public health authorities due to the serious threat to the human health. The unicellular algae implicated in the production of diarrhetic shellfish poison (DSP) mainly belong to the genus *Dinophysis* (Sedmak & Fanuko, 1991). The first documented occurrence of a massive toxic bloom in the Slovenian part of the Adriatic was in October 1984. A massive occurrence of potentially harmful *Gymnodinium* and *Alexandrium* species was detected and several gastrointestinal intoxication reported (Fanuko *et al.*, 1989; Mozetič *et al.*, 1997). From there on toxic blooms occurred almost on a regular basis. Due to the detection of biotoxins in mussel's tissue and identification of harmful toxic algae in the Slovenian part of the Adriatic in the last decade, maricultures were not temporary closed only in 1991 and 1992. In all cases toxic blooms occurred in mid or late summer or early autumn, except in 1993 when maricultures were closed from mid October to the end of November and in 1989 when production and sale of mussels were banned for almost half a year, from late September to the beginning of March 1990 (Sedmak & Obal, 1998). In 1996, two human intoxication by DSP were reported in Slovenia, while many others probably passed unnoticed because of the similarity of DSP symptoms to other gastrointestinal infections (Malej *et al.*, 1994). The shellfish species that accumulate the largest amounts of toxins are edible mussels *(Mytilus galloprovincialis).* These mussels are also the main mussels grown in maricultures. Other shellfish that appear on the fishmarkets and are commonly eaten are Pilgrim's scallops *(Pecten jacobeus),* oysters *(Ostrea edulis),* warty venus shells *(Venus verrucosa),* and checkerboards *(Venerupis decussata).* These could also be affected by harmful toxins, but generally accumulate less toxins and are less often available on the fishmarkets for larger consumption.

Toxins implicated in DSP intoxication are acidic okadaic acid (a strong tumor promoter and protein phosphatase inhibitor), dinophysis toxin-1, -2 and -3 (DTX-1, DTX-2, DTX-3) and several polyether lactons named pectenotoxins (PTX). Another class of polyether toxins - yessotoxins (YTX) - were also found in the Adriatic mussels from the Emiglia-Romagna coast (Ciminiello *et al.*, 1997). Ingestion of YTX could also induce neurological symptoms in intoxicated persons although so far, other toxins that cause amnesic (ASP), paralytic (PSP) or neurotoxic (NSP) symptoms have not been detected in the Adriatic mussels.

The periodical but regular occurrence of toxic algal blooms in the northern Adriatic is a serious threat to public health and to the local economy. It is beyond the scope of this paper to discuss problems associated with toxic algal blooms but a suitable measures of protection, monitoring and legislature are required in order to control this phenomena (*e.g.* Sedmak & Obal, 1998).

Marine sponges

Marine sponges are known to be true "chemical factories" producing an impressive number of unique substances with a broad spectrum of biological activities. Some tropical species are known to produce severe contact dermatitis and itching (Mebs, 1995; Fisher, 1978) but the majority is considered harmless and no harmful effects on man from the Adriatic sponges have been reported so far. There are, however, well documented reports from the Mediterranean on the so-called sponge divers disease which in fact occurs due to repetitive stings by an anemone (*Sagartia elegans*) attached to the sponges at the depth of 25-45 metres (Zervos, 1934; Halstead, 1988). With a decline of commercial sponge collecting, this disease became extremely rare. Treatment is symptomatic: non-ineffective but unresponsive skin reaction may respond to a short (up to 3 days) course of systemic steroid application under medical supervision.

The lack of appropriate structures for injection of toxic substances and the fact that sponges are not eaten by humans put sponges far from being considered a hazard to human health. Nevertheless, sponges are one of the prime targets in search of novel substances that might be useful in treatment of various diseases from AIDS to cancer. As an example, in aqueous extracts of just 21 northern Adriatic sponges we found hemagglutinating, haemolytic, antibiotic, cytotoxic and anticholinesterase activity (Sepčić *et al.*, 1997) With no doubt we can conclude that what we know about sponges is just a scratch under their surface. Many new and important chemical substances could be expected from their bodies in the future.

Coelenterates

Coelenterates (Cnidaria: sea anemones, jellyfish and hydroids) represent, with no doubt, toxicologically the most important group of marine organisms. Some of their venoms are so powerful that can kill an adult within minutes. There are several members of the class that inflict upon contact painful stings with sometimes serious consequences (see Williamson & Burnett, 1995). In the Northern Adriatic there are several cnidarians that could be harmful to man, but usually envenomation is moderate and does not present a serious threat to the victim.

The most notorious example of the venomous jellyfish from the Adriatic is the massive occurrence of Mauve stinger jellyfish (*Pelagia noctiluca*) in the late seventies and early eighties (Maretić *et al.*, 1980; Maretić & Russel, 1983). This species was so abundant that represented a serious threat to the tourist economy of the

Mediterranean countries. Thousands of people were stung by this relatively small jellyfish. Most of the victims developed only local reactions, in some hyperpigmentation of the skin developed that persisted for month, and there were few reports of systemic reaction and even anaphylactic shock (Togias *et al.*, 1985).

Other potentially dangerous jellyfish that occurred along the north Italian Adriatic coast is the cubomedusa *Carybdea marsupialis* (Avian *et al.*, 1992; Rottini *et al.*, 1995). Contact with this jellyfish has been reported to cause erythematous-vesicular eruptions over the skin, accompanied by pain and a strong burning sensation. Skin lesions my also be observed in more susceptible individuals (Kokelj *et al.*, 1992, 1993).

Other species of jellyfish that are sporadically common in the Northern Adriatic are *Cotylorhiza tuberculata, Rhizostoma pulmo, Aurelia aurita,* and *Chrysaora hysoscella*. Although some reports list these species as stingers (*e.g.* Kokelj *et al.*, 1989), a personal experience of the author cannot confirm these reports. However, it is possible that in susceptible individuals these jellyfish may also inflict a painful sting and one should be cautious in handling them with bare hands. Most of the jellyfish venoms contain cytolysins, but they are difficult to isolate in pure form since they are extremely heat labile and prone to the denaturation from various other reasons. The ambiguity in this field of research is therefore large and no firm conclusions about the composition of jellyfish venom have been made.

Sea anemones (Actiniaria) are another representative of the cnidarians that can inflict a painful sting. Although all sea anemones contain very powerful and even lethal toxins in their nematocysts, there are only few species that can pierce human skin and cause envenomation. *Anemonia sulcata* is one such species living in shallow waters and rocky pools of the Adriatic, sometimes covering large areas. This species is photophylic and could persist even in polluted waters. Small children that often play in the rocky pools are especially prone to the envenomation since their skin and mucosa are more tender. The affected area of the skin takes on a reddened and slightly raised appearance, bearing irregularly scattered pin-head size vesicles and sometimes an edema may develop around the injured skin. On lips and child skin larger blisters can develop. The area becomes painful, particularly to touch and heat (Maretić 1975; Maretić & Russel, 1983). There are some other sea anemones that could cause unpleasant consequences upon contact with their tentacles, *i.e.* the already mentioned *Sagartia elegans* and two rare species whose existence in the Northern Adriatic is doubtful: *Alicia mirabilis* and *Cladastis costae*. The touch of the latter (Pelješac peninsula, Southern Adriatic, personal experience, 1987) was quite painful and a burning sensation with erythrema of the hand lasted for several hours. Most sea anemones possess peptide neurotoxins that block sodium or potassium channels in nerves. Many also possess protein cytolytic toxins that are, however, different from those found in jellyfish. No special treatment of sea anemone stings is needed. In most cases a topical ointment like Kamagel will ease the pain and the symptoms. In small children precaution is needed in order not to spread undischarged nematocysts over the body and in the vicinity of mouth and eyes.

In the case of jellyfish stings, treatment of the victim depends on species involved.

For *Pelagia* stings washing with sea (not tap) water and application of ice is recommended. If symptoms persist or worsen one should seek medical attention, and especially if signs of anaphylactic shock develop this should be done without any hesitation. In the case of a *Carybdea* sting, the remaining nematocysts should be first neutralised by vinegar and then by ice packs for pain relief. One should seek medical help if symptoms persist or worsen.

MOLLUSCS (MOLLUSCA)

The only toxic molluscan species in the Northern Adriatic is the Mediterranean cone snail (*Conus mediterraneus*). However, no reports exist about the composition of its venom and possible envenomation in humans. Nevertheless, one should be careful in handling this cone since some of its tropical cousins are known to possess in their venoms a vast array of peptide toxins that can easily cause human death. The Mediterranean cone is a greenish brown cone shaped snail, but its shell is often variable and covered with bryozoans.

ANNELIDA (POLYCHAETA)

Some of the bristle worms are capable of inflicting painful wounds by their hollow and brittle setae, filled with toxins. Such species are those from the genera *Eurythoe, Aphrodita* and *Hermodice*. Fire worm (*Hermodice carunculata*) is a large up to 25 cm long segmented worm. Each of the segments bears on both sides numerous white setae that are extremely fragile upon contact. According to Penner (1970), the contact with bristleworm *H. carunculata* produced pain and transient numbness of the hand when setae were broken off in the skin. The pain or stinging sensation persisted for more than 12 hours, and the numbness of the entire extremity lasted for about 30 minutes. He suggested that the setae be filled with neurotoxin, which was emptied into the wounds when the bristles broke off. *Hermodice carunculata* could be found at various depths. Because the worm is a scavenger, it could be usually found over dead marine creatures. People (except SCUBA divers) only occasionally come in close contact with this worm. Care should be exercised to avoid touching this and other polychaete worms with bare hands.

ECHINODERMATA

Sea urchins are a nuisance well known to bathers who dare to venture into the water barefooted. Although the majority of sea urchins are not toxic, their fragile broken spines that were not entirely removed from the skin tend to get inflamed due to the bacterial infection. Granuloma and vesiculation of the skin around the broken particle are common, and sometimes surgical approach is needed to remove the spine. In the Adriatic the usual culprits are the violet sea urchin (*Paracentrotus lividus*) and black sea urchin (*Arbacia lixula*). The latter is less common, but contact with its extremely fragile spines tends to be more painful and broken particles are more difficult to remove. The only sea urchin in the Adriatic possessing venomous glands is the one that could be handled with bare hands without any consequences. *Sphaerechinus granularis* belongs to the Toxopneustidae family of sea urchins, which are toxic. *S. granularis* is no exception, but its venomous pedicellaria (Peres, 1950) are too weak to pierce the human skin, its spines are blunt and difficult to break. Another potentially dangerous species because of its extremely long spines is the Mediterranean diadema urchin (*Centrostephanus longispinus*). However, this sea urchin lives only in the southern part of the Adriatic. It is unlikely for us to encounter its spines since its habitat is bellow 50 m. This species belongs to the diadema sea urchin family whose members are a real threat to the unaware tourists in the tropics.

Among other echinoderms sea stars and holothurians are known to possess or excrete different toxic substances with predominant hemolytic activity. The majority of them are saponins, holothurin being probably the most examined substance of this class (Habermehl & Volkwein, 1971). The noxious taste of these compounds probably repel potential predators, but they do not affect human beings.

Fig. 1: Snake locks anemone (Anemonia sulcata) *possesses several neurotoxins. A touch by its tentacles could be painful, especially with small children.*
Sl. 1: Voščena morska vetrnica (Anemonia sulcata) *vsebuje številne nevrotoksine. Dotik njenih lovk je lahko boleč, zlasti pri majhnih otrocih.*
Fig. 2: Compass jellyfish (Chrysaora hysoscella) *is quite common, but its stings are very mild.*
Sl. 2: Kompasni klobučnjak (Chrysaora hysoscella) *je razmeroma pogost, dotik z lovkami pa ne pušča hujših posledic.*
Fig. 3: Mediterranean cone shell (Conus mediterraneus) *is the only venomous gastropod in the Mediterranean.*
Sl. 3: Sredozemski stožec (Conus mediterraneus) *je edina strupena vrsta polža v Sredozemlju.*
Fig. 4: Purple sea urchin (Sphaerechinus granularis) *is the only venomous sea urchin in the Adriatic. However, its spines are blunt and venomous pedicellarea too weak to pierce the human skin.*
Sl 4: Pegasti ježek (Sphaerechinus granularis) *je edini strupeni morski ježek v Jadranu. Ker pa so njegove bodice tope, ščipci pa šibki, človeku ni nevaren.*
Fig. 5: Weevers are without much doubt the most venomous fish in the Mediterranean. Streaked weever (Trachinus radiatus) *can reach the length of 50 cm and should be treated with respect. Envenomation is extremely painful, but fortunately its venom is thermolabile.*
Sl. 5: Morski zmaji so nedvomno najbolj strupene sredozemske ribe. Črnoglavi morski zmaj (Trachinus radiatus) *lahko doseže do 50 cm dolžine, zato moramo biti ob srečanju z njim še posebno previdni. Vbod morskega zmaja je ekstremno boleč, k sreči pa je strup termolabilen.*
Fig. 6: A related species is the greater weever (Trachinus draco). *In the Northern Adriatic this species is more abundant but is usually smaller. Its venom is equally efficient as the venom of its relative, the streaked weever. Greater weevers are usually buried in the sand.*
Sl. 6: Sorodna vrsta je morski zmaj (Trachinus draco). *V severnem Jadranu je ta vrsta bolj pogosta, vendar doseže nekoliko manjšo velikost. Strup morskega zmaja je enako učinkovit kot strup sorodnega črnoglavega morskega zmaja. Morski zmaji so pogosto popolnoma vkopani v pesek.*
Fig. 7: Scorpion fish are a common sight underwater, but can be easily overlooked due to their cryptic coloration while lying motionless on the sea bottom. There are several species with venomous spines that can inflict painful wounds, although less serious compared to the weevers stings. The biggest species in the Adriatic is the red scorpionfish (Scorpaena scrofa).
Sl. 7: Z bodikami se pod vodo pogosto srečamo, čeprav jih zaradi njihove barvne prilagojenosti okolju in nepremičnemu ležanju na dnu velikokrat tudi spregledamo. Poznamo nekaj vrst, vse imajo strupene bodice, ki lahko povzročijo boleče rane, čeprav so te manj hude od vbodov z bodicami morskih zmajev. Največja bodika v Jadranu je rdeča bodika (Scorpaena scrofa).
Fig. 8: Sting rays and eagle rays possess one or two long venomous spines protruding from the base of their tails. Encounters with these fishes are, except on fishing boats, rather rare. Common sting ray (Dasyatis pastinaca) *is the most common stingray in the Adriatic. It can reach the length of up to 1.5 m. (All photos by T. Turk)*
Sl. 8: Strupene ribe v Jadranu so še morski biči in morski golobi. Obe skupini rib imata po eno ali dve dolgi strupeni bodici, ki štrlita iz repnega korena. Srečanja s temi ribami, razen na ribiških ladjah, so redka. Na sliki je morski bič (Dasyatis pastinaca). *Največji ulovljeni osebek je bil dolg 1,5 m. (Vse fotografije: T. Turk)*

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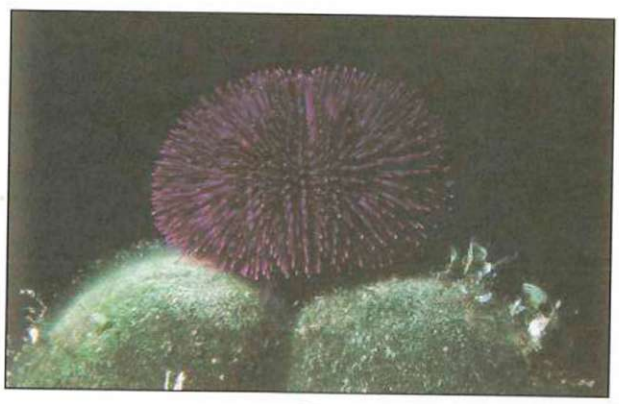

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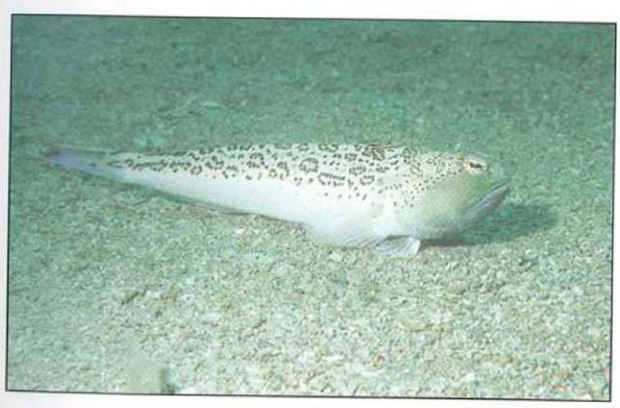

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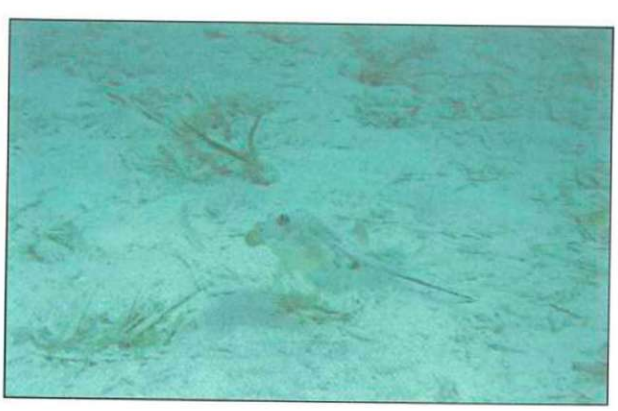

8

FISH
Venomous fish

Venomous fish are probably of the greatest medical importance in the Northern Adriatic since they are frequently encountered by fishermen, divers and bathers. Without much doubt the most venomous fish of the Mediterranean are weever fishes. There are four species living in the Adriatic: very common greater weeverfish *Trachinus* (recently renamed to *Echichthys) draco*, fairly common streaked weever *(T. radiatus)*, less common spotted weever *(T. araneus)*, and very rare lesser weever *(T. vipera)*. The latter is also the smallest but considered the most venomous. Weevers are small to medium sized fish, the largest documented one caught near Pula was a specimen of *T. radiatus*, measuring 53 cm and weighting 1550 g (Maretić & Vejnović, 1990). They are benthic fish lying motionless on the sea bed, frequently they bury themselves into the sand with eyes, head and dorsal and opercular spines exposed. They live at various depths, but in summer when spawning takes place, they could be found in very shallow water. The common features of all weevers are their venomous spines of the dorsal fin (DI) and an additional dagger-like opercular spine on each side of the head. Grooved spines are lined with glandular cells that produce venom. The isolation of fish toxins from crude venom preparations is one of the most challenging problems in toxinology. Weevers are no exception in this regard. Toxic components of the venom are extremely unstable at room temperature. It was not until 1992 when dracotoxin, a main toxic component of crude *T. draco* venom preparation, has been isolated. Dracotoxin is 105 Kda hemolytic protein showing high affinity for rabbit red blood cells. It causes depolarisation of rat brain particles and is lethal to mice (Chhatwal & Dreyer, 1992a, 1992b). It is quite possible that dracotoxin possesses also additional biological activities that may be responsible for the clinical picture seen in human envenomations.

Envenomation with weevers most often occurs in inexperienced tourist fishermen who are not aware that grabbing and handling a struggling weever on the hook line may end with serious consequences. Less common, but still important, are accidents in sandy shallow waters where bathers are swimming and wading barefooted on the sea bed and being stung by stepping on the buried weever. In the Pula Medical Centre, out of 257 patients stung by different species of weevers only 41% were local people, while the rest were tourists (Maretić, 1982). The weeverfish sting is extremely painful, victim may scream of the excruciating pain. The instantaneous burning pain is probably due to the large amounts of 5-hydroxytriptamine and histamine in the venom (Carlisle, 1962; Chhatwal & Dreyer, 1992b). Soon pain comes to involve the entire affected limb and within 30 min or so increases to reduce the patient to writhing and sometimes screaming incoherence (Halstead, 1988). Local swelling and erythema quickly follow and in neglected wounds significant local tissue damage, protracted morbidity of the limb and secondary bacterial infection may occur. Death cases are documented (Skeie, 1962a, 1962b; Carlisle, 1962; Maretić, 1988) but at least three of them were due to delayed septicemia.

Fortunately, because venom components are extremely heat sensitive and labile, hot water immersion is an effective remedy for weeverfish (as well as other venomous fish) stings. The temperature of the water should be comfortable enough for the patient, hot enough to provide relief but not too hot to cause burns. In more serious cases an antivenin against *Trachinus, Scorpaena* and *Uranoscopus* that effectively relief the symptoms within minutes is available, produced by the Imunološki institut in Zagreb.

Stargazers *(Uranoscopus* spp.) are closely related to weevers but the reports about their toxicity are ambiguous. They have two sharp dorsal spines and an opercular spine, but according to Halstead (1988) they do not possess venomous glands, therefore they are considered nonvenomous. However, Gerhardt and Delange (1999) claim that the Mediterranean stargazer *(Uranoscopus scaber)* possesses venomous spines. In man, accidental stings provoke acute pains and twinges that last, if untreated, for about 24 hours. Nevertheless, stargazer venom seems to be far less toxic than that of weevers or the scorpion fish.

Scorpion fishes (Scorpaenidae) are well known for their venomous spines in their front dorsal fin and numerous opercular spines. Scorpion fish are masters of camouflage and lie motionless on the sea bottom. According to Maretić (1982a), most accidents occur with housewives who clean the fish and accidentally get stung. There are four species living in the Northern Adriatic: black scorpionfish *(Scorpaena porcus)*, red scorpionfish *(S. scrofa)*, small red scorpionfish *(S. notata S. ustulata)* and Madeira rockfish *(Sebastes maderensis)*. Symptoms of envenomation due to the sting are painful and similar to those of weevers, but generally milder. Recommended treatment is the same as in weever's sting.

It is quite unlikely to get stung by one of the members of eagle rays (Myliobatidae) or stingrays (Dasyatidae). Since this animals can reach considerable size one should be aware of their venomous, harpoon like, barbed spines (transformed dorsal fins) protruding from their tails. In large specimens these spines can reach up to 20 cm and are a respectable weapon that is not only venomous but can also cause deep traumatic injuries. Because these fishes are cautious and usually live in greater depths, accidents in the Adriatic are very rare. However, in certain part of the world, like in California, they contribute to the majority of fish envenomation. The major culprit there is the stingray *Urobatis halleri* (Maretić, 1982a). Eagle ray or stingray stings cause acute

pain, redness and edema around the wound. General symptoms are malaise, nausea and sweating. Anxiety, salivation, vomiting, diarrhoea, troubles in respiration, blurred vision, paresthesias and shock have also been described (Halstead, 1970). Treatment is symptomatic, immersion in hot water is recommended for pain relief, but larger wounds should be also treated surgically. To avoid accidents with stingrays and eagle rays, great care should be exercised, especially with large caught specimens that can trash around with their tail and cause injuries of vital organs.

Fish poisoning

Moray eels, to the contrary of their fierce and evil look and popular belief that they are venomous, do not possess any venom glands. Nevertheless, their bite could cause serious bacterial infection. Mediterranean moray eel *(Muraena helena)* that is rare in the Northern Adriatic, conger eel *(Conger conger)*, and eel *(Anguilla anguilla)* are, however, cryptotoxic since they have poisonous blood.

Another form of fish poisoning (ichthyotoxism) is also possible by ingesting certain fish of Scombridae family which is, however, due to the improper storage of the catch and not to their endogenous toxins. Scombrotoxism or scombroid fish poisoning is due to the large content of histamine released from the flesh of mackerels and other fish of the Scombridae family. The reason is improper storage of fish that enables bacteria in releasing histamine from the fish muscles. A peppery taste of the fish indicates a high level of histamine. Symptoms are typical of histamine poisoning, including headache, dizziness, nausea, vomiting, generalised erythema and urticaria, followed by diarrhoea, extensive pruritus, and in severe cases bronchospasm and respiratory distress. Shock and even death my follow in untreated severe cases (Taylor *et al.*, 1989). Treatment is carried out with antihistaminic drugs. In the former Yugoslavia a case of massive scombrotoxic poisoning was reported in 1981 (Maretić, 1982b). Scombrotoxism is an important public health issue and canned fish may also be implicated (Murray *et al.*, 1982).

CONCLUSIONS

We can conclude that marine organisms in the Northern Adriatic usually do not represent a serious threat to public health. Nevertheless, the knowledge about their biology, ecology and harmful substances they possess is important in order to act properly when individuals or even larger population are affected by their toxins or venoms.

STRUPENI ORGANIZMI SEVERNEGA JADRANA

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POVZETEK

V severnem Jadranu živi občasno ali stalno nekaj vrst strupenih morskih organizmov. Čeprav ne pomenijo resne nevarnosti za zdravje ljudi, si zaslužijo našo pozornost in znanje o njihovi biologiji, ekologiji in strupenih snoveh, ki jih najdemo bodisi v njihovih telesih bodisi v strupnih žlezah. Veliko večino organizmov v vodah severnega Jadrana, ki v določenih razmerah lahko postanejo strupeni, prištevamo k drobnim enoceličnim planktonskim oklepnim bičkarjem (Dinophyta). Množična cvetenja dinoflagelatov so najhujša grožnja zdravju ljudi, saj se ti toksini kopičijo v tkivih školjk, kot so npr. klapavice (Mytilus galloprovincialis). *Veliko toksičnih snovi vsebujejo tudi spužve (Porifera). Tu in tam lahko postanejo strupene tudi nekatere ribe iz družine skuš (Scombridae), kar pa je v glavnem posledica nepravilnega shranjevanja ulova in posledično velike vsebnosti histamina v tkivu ujetih rib. Tiste strupene živali, ki imajo strupni aparat in strup direktno vbrizgajo v telo žrtve, spadajo v različne skupine, tudi v severnem Jadranu pa jih je največ med ožigalkarji in ribami.*

Ključne besede: strupeni organizmi, zdravje ljudi, severni Jadran

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